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The American Midland Naturalist

Devoted to Natural History, Primarily that of the Prairie States

Founded by J. A. Nieuwland, C.S.C.

Contents

Phytogeographical Problems of Eastern Canada—*Frère Marie-Victorin* 489
The Vegetation of Muskogee County, Oklahoma—*Elbert L. Little, Jr.* 559
The Species-Area Curve—*Stanley A. Cain* 573
Further Studies in Southwestern Oaks—*Cornelius H. Muller* 582
Layering in Black Spruce (Picea mariana [Mill.] BSP.)—*Frank C. Gates* 589
Observations on the Distribution of Heuchera arkansana Rydberg—*E. L. Nielsen and O. R. Younge* 595
Studies in the Anacardiaceae. III. A Note Concerning the Status of Rhus pulvinata Greene (R. glabra x typhina Koehne)—*Fred A. Barkley* 598
Some Blood Parasites from Nebraska Birds-II.—*G. Robert Coatney and Evaline West* 601
A Description of Phyllodistomum caudatum n.sp.—*C. M. Steelman* 613
A Remarkable Infection of Tapeworm Larvae in a Whipsnake—*W. E. Hubbard* 617
Tardigrada from North America—*C. B. Mathews* 619
Records of Distribution of Species of Isopods in Central and Southern United States, with Descriptions of Four New Species of Mancasellus and Asellus (Asellota, Asellidae)—*L. Hubricht and J. G. Mackin* 628
Family Names in the Order Araneae—*B. J. Kaston* 638
New Moss-Mites, Chiefly Midwestern-III—*Arthur Paul Jacot* 647
Generic Check List of Aphids and Phylloxera—*Forrest W. Miller* 658
The Life-History and Habits of the Digger-Wasp, Ammobia pennsylvanica (Linn.)—*J. A. Frisch, S.J.* 673
A New Ant from Idaho's Semidesert—*A. C. Cole, Jr.* 678
The Size of Certain Naiades from Western Lake Erie in Relation to Shoal Exposure—*C. J. D. Brown, Clarence Clark and Bruce Gleissner* 682
Observations on the Natural History of Pomatiopsis lapidaria Say—*Donald J. Ameel* 702
On Some Cenozoic Brachiopoda from the North American Region—*Kotora M. Hatai* 706
Pentameridae of the Cedar Valley Beds of Iowa—*Merrill A. Stainbrook* 723
A Cranium of the Extinct Moose, Cervalces, from the Quarternary of Northern Indiana—*C. Lewis Gazin* 740
Book Reviews 742

Vol. 19 MAY, 1938 No. 3

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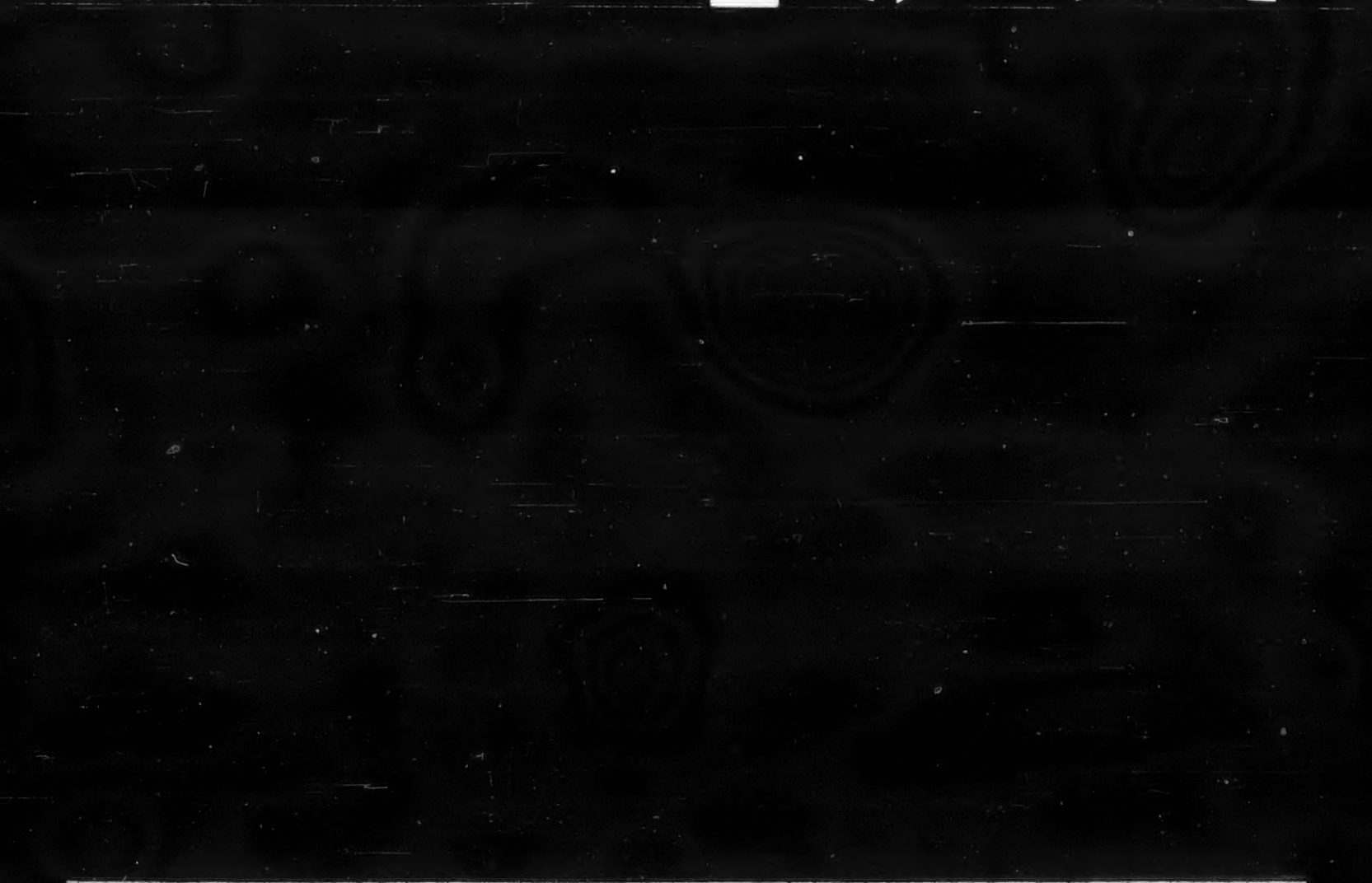

The American Midland Naturalist

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VOL. 19 MAY, 1938 No. 3

Phytogeographical Problems of Eastern Canada*

Frère Marie-Victorin

The purpose of this paper is to discuss some biological and historical features concerning the flora of Eastern Canada: questions of origin, questions of behavior and dynamism, questions of present and past geographical distribution, questions of isolation and extinction.

Floras are dynamic units undergoing constant transformations. Their apparent static condition is a delusion, relevant to the short span of human life, and of human experience as a whole.

There has been in the floras of the past a dynamism which, displayed on the general geological background, stands out so prominently that it can hardly be questioned in the present state of science. Plant groups, featuring original novelties in life structures, have appeared more or less suddenly in the dim past, have shooted, seemingly by mutations, a rich array of forms. In the end, however, having exhausted the possibilities of the basic types, having become fixed, whole groups of plants have disappeared from the face of the world, leaving, for us to read, scanty engraved records among the rocks.

Over the stage of Time have passed those primitive dummy figures of vascular plants, the Devonian Psilophytales: *Psilophyton* of Gaspé, *Rhynia* of Scotland, mere shadows cast ahead by life in the making, plants where no differentiation of the vegetative body into root, stem and leaves was yet obvious. Then marched on the graceful legions of Pteridosperms, fern-like seed-bearing plants. A dream-like picture! A forest canopy of immense lacy fronds with fruits as large as plums hanging underneath! A forest floor carpeted with a thick and continuous layer of golden pollen. And later, unfolding under the sun of what are now the Dakotas, the strange Cycadeoideas, things of beauty two feet across, striving to become real flowers! They were only of course clusters of branching stamens, and had not yet evolved the showy structures which we call petals and corollas, but they were heralding, together with the Caytoniales, — those strange "angiospermic ferns" of the Middle Jurassic, — the advent of the gorgeous multitude of Angiosperms: the

* Based on a lecture entitled "The Vanishing Floras of Northeastern America" and delivered on the occasion of "The Julius Arthur Nieuwland Memorial Exercises" held at The University of Notre Dame, January 10, 1937.

roses, the lilies, the orchids, and what not? silent and lovely things that brighten the world we live in to-day.

Psilophytales, Pteridosperms, Cycadeoideas, Caytoniales, they are all gone. They had vanished hundreds of millions of years before stone age man ever stood gazing in front of his cave, wondering at the already weathered world to which he has been bringing a rejuvenating and powerful ecological factor: the human mind.

They have vanished, but the flow of life is still as bubbling as ever, pushing through its devious course, opening new channels, turning away from the old ones. The restless and irreversible stream of life is with us, within us, around us. Our living flora is undoubtedly on the march. Its present figure is a short episode that will be soon a thing of the past.

Is it possible to detect in the living flora of our own portion of the biosphere, — let us call it eastern Canada, — obvious and measurable manifestations of this permanent dynamism? Is it possible to feel the pulse of this great vital current of which we know neither whence it has come, nor whither it goes?

What are the influences which, at the present stage of life's history, govern the changes of this more or less defined unit? If life travels along a certain line, how can we mark the present position?

The possibilities concerning the dynamic or static condition of a flora are rather few. Does this flora represent a primitive and undisturbed equilibrium? Or, after a long, onward march, has it reached a mature phase, a senile condition where its dynamism is exhausted? Or, is it rather a phase in a phenomenon of movement, a point on an open curve?

To look at our living flora as having preserved an undisturbed primitive equilibrium, is a geological and biological absurdity, especially in this old land of the Laurentian shield, time and again buried under seas, now a mountain range, and now eroded into a peneplain; and finally base-leveled and polished by repeated Pleistocene glaciations.

The conception of a life-complex which has come to rest after a long display of dynamism during geological ages can be viewed as a possibility by the scientific layman. Certain descriptions of natural habitats found in the early records of American discovery seem to hold true to this day. Thus a few lines from Jacques Cartier's travels, describing the vegetation of the sand dunes of Brion, on the Magdalen Islands, seem to have been written yesterday:

> Cestedite ille est la milleure terre que nous ayon veu, car vng arpant d'icelle terre vault mieulx que toute la terre Neufve. Nous la trouvames plaine de beaulx arbres, prairies, champs de blé sauvaige, et de poys en fleurs, aussi espès et aussi beaulx, que je vis oncques en Bretaigne, queulx sembloict y avoir esté semé par laboureux. Il y a force grouaiseliers, frassiers et rossez de Provins, persil et aultres bonnes erbes, de grant odeur. (BIGGAR, H. P.: *The voyages of Jacques Cartier, pp. 33-34*).

The book in hand, I have walked the sands of Brion three centuries after

the great discoverer. And still could be seen the so-called "Wheat" *(Elymus arenarius* var. *villosus)*, that most interesting sturdy grass of the sandy seashore, which never ventures inland; the deliciously fragrant Ladies' Tresses *(Spiranthes Romanzoffiana)*; the remarkably large-fruited Strawberry *(Fragaria virginiana* var. *terrae-novae)*; the large Cranberry *(Vaccinium macrocarpon)*. There also were the Scotch Lovage *(Ligusticum scothicum)* and the coastal plain Rose *(Rosa virginiana)*, thousands of pink stars over the sandy tract (Fig. 1).

Fig. 1. Sand dune association *(Rosa virginiana, Fragaria virginiana* var. *terrae-novae, Ammophila breviligulata, Spiranthes Romanzoffiana,* etc.) on Brion, Magdalen Islands, Que., substantially to-day as described by Jacques Cartier in 1534. (Photo Marcelle Gauvreau).

Macoun the elder found Michaux's unmistakable station for *Primula mistassinica*, after a century. In the same way not only aggregate Linnaean species, but mere micromorphs are apparently static. Michaux's type of *Artemisia canadensis* is one of several micromorphs of this species growing on the sands of Lake St. John. After a century and a half, the writer found, identical in all details the exact micromorph which Michaux, or better Louis-Claude Richard had in hand when describing the species.

Using a too well-known method, one might multiply greatly the facts and evidences of this nature, selecting and sorting them in order to build up a demonstration of the stability of plant populations, demonstration which might be entirely satisfactory to the layman. But, — centuries being in the history of life what mere seconds are in written history, — to the geologically and biologically trained mind, these facts and testimonies express but a lure of stability.

In the same way, may we speak of the stability of our social and economic institutions, of the permanence of our laws and political charters. But all this in no way invalidates the more general reality of the movement of all that is.

It would be extremely unlikely that plant associations, after all just a perishable living net spread over the granite shoulders of an old mountain range beaten and scarred by Time, should escape the Heraclitean law and be fixed and immutable. Plant life is function of environmental conditions unceasingly undergoing transformation. Plant associations and their units must then continually adapt themselves to new combinations of physiological and physiographical factors, and mold themselves to the changing environment. While this goes on, insufficiently plastic species drop out, while new and more suitable forms are produced to fill the gaps. The ultimate result in some sort of an apparently preserved equilibrium.

Even though we are mainly dealing with the fluctuation or evolution of the units themselves, it is worth while to devote a moment of attention to the dynamism of the associations.

Plant mosaics with interchangeable components are sometimes evident in space as well as in time. No botanist who visits Lake St. John in northern Quebec would fail to notice the extensive sands accumulated on the north side, by the age-long erosion of the great feeders of the lake: Ashuapmouchouan,

Fig. 2. Early stage of the *Pinus Banksiana-Comptonia asplenifolia-Solidago puberula* association, on the north shore of Lake St. John, Que. (Photo Marie-Victorin).

Mistassini and Peribonka rivers. The primitive forest here has been cut and burnt long ago. Owing to the scanty micro-flora of these sterile denuded soils, a very simple association rules over large tracts of ground. There reigns supreme the calcifugal *Pinus Banksiana*, one of the American allies of *Pinus sylvestris* of Europe. The individual pines usually stand somewhat apart and leave room for the common xerophytic chamaephytes so characteristic of acid soils in the north (Fig. 2). Here the chamaephytic part in the cast happens to be played by just one species, *Comptonia asplenifolia*. But the dense growth of *Comptonia* nevertheless leaves small gaps which, on account of the peculiar light conditions, can accommodate only such species, as for example

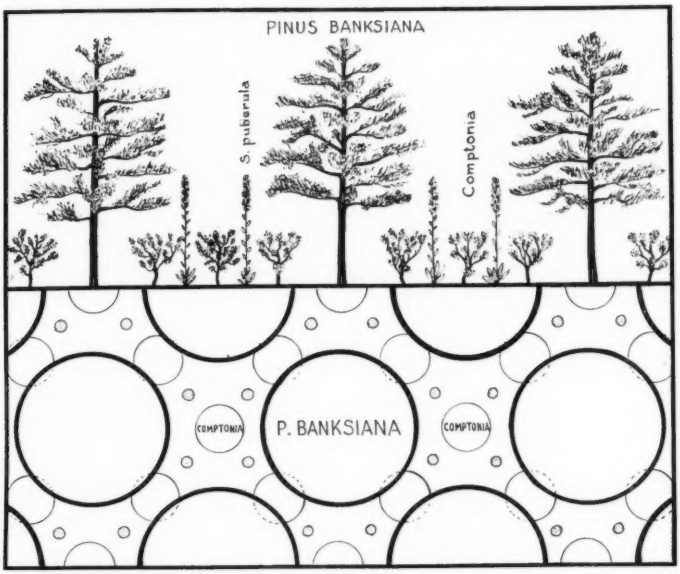

Fig. 3. Vertical and horizontal diagrams of the *Pinus Banksiana-Comptonia asplenifolia-Solidago puberula* association, a beautifully schematic mosaic arrangement, general on the great sandy areas of the Lake St. John district, Que. (J. Brunel, del.)

Solidago puberula, equipped to push a long virgate inflorescence through the dense foliage. The *Pinus Banksiana — Comptonia asplenifolia — Solidago puberula* association of the Lake St. John sands is one of the most beautifully schematic phytomosaic patterns to be seen anywhere (Fig. 3).

But the three units forming this particular phytomosaic are not so strictly defined and bound together that one of them cannot be replaced by a substitute of the same biological type. In fact, *Pinus Banksiana* can be replaced by *Pinus resinosa; Comptonia asplenifolia* by some ericaceous ecological equivalent *(Kalmia angustifolia, Rhodora canadensis, Vaccinium angustifolium, Vaccinium canadense);* and *Solidago puberula* by other virgate Goldenrods: *Solidago squarrosa* or *Solidago macrophylla.*

To sum up, plant associations are living mosaics where, in accordance with the physical evolution of the ecological factors, and often independently, changes or substitutions in the units are slowly made. The equilibrium is that of the whole, and not necessarily that of the component parts. The mathematical product remains the same during long periods, but the sequence, order, and value of factors are submitted to ceaseless variations.

There remains the view that our present floras are a phase in a phenomenon of movement, a point on an open curve, or, — to put it in standard biological language, — that our modern floras are still in full evolution.

The general thesis of plant evolution I do not care to develop here. Let it be sufficient to state that the critical study of the flora of eastern Canada has undoubtedly supplied fresh evidence that plant life continues a development initiated very long ago; that new systematic entities: species and varieties, seem to be actually in the making, and that the dynamic possibilities of plant life are no more exhausted by the present development of species, than by the normal ontogeny of individuals.

The experimental method is, of course, out of question here, with "ensembles" of such magnitude and complexity, where the Time factor cannot be eliminated. Observation, comparison, and induction are the only courses possible.

Observation of plants, comparison of their features, and mapping of their ranges show that there are endemic species, that is species with a limited and consistent distribution. By the same methods it also becomes evident that there are epibiotic species, that is survivors of extinct floras or associations, persisting as relics far away from their main present ranges.

It seems that, by the careful study of environmental factors, and of distribution, one can measure the minute morphological deviations undergone by epibiotic species. It also seems reasonable to explain the origin of endemics either by slow and continuous transformations, a Darwinian or Lamarckian process, or by sudden saltations, a mutational or DeVriesian process.

Jules Tannery has pointed out that human minds have always been, and will always be, divided by two main tendencies. Some are mainly on the lookout for continuity, others persistently seek and find discontinuity. The history of mathematics, that of physics, hinge on these opposite instinctive human tendencies. Biological science could not develop otherwise, and this inherent duality has become evident once more when biologists have sought to fathom the mystery of evolution, — when they have become eager to measure the rate of flow of the majestic river of Life.

Both these points of view will probably be needed to tell the whole story of plant evolution, if such a story can ever be told. The least that can be said is that good example of discontinuous evolution can be found even in the restricted flora of eastern Canada.

Fig. 4 shows for comparison the head of the huge fleshy *Senecio pseudo-Arnica* of the Gulf of St. Lawrence, and that of its mutant *Senecio Rollandii*.

In Mingania[1] large colonies of *Senecio Rollandii* stand clearly, and without transitions, out of the continuous line of *Senecio pseudo-Arnica* bordering the seashore. In Fig. 5, the zone in the foreground is formed of *Elymus*

1 I have ventured to coin the name "Mingania" for the striking geographical and biological unit formed by the Mingan Islands, on the north shore of the Gulf of St. Lawrence, opposite Anticosti Island.

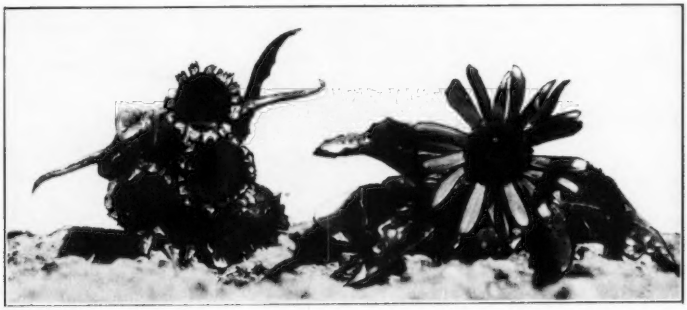

Fig. 4. Heads of *Senecio pseudo-Arnica* (right) and its mutant *Senecio Rollandii* (left), the latter a purplish plant with very short rays. (Photo Marie-Victorin).

arenarius var. *villosus*. Then comes behind the zone of the halophytic succulent *Senecio*. The vertical line sharply separates *S. pseudo-Arnica* from its mutant *S. Rollandii*.

A parallel situation obtains for several others of our northeastern species of *Senecio*, and in other genera of the family Compositae. I remember well having seen at La Loutre River, on Anticosti Island, a Sphagnum bog filled with the discoid mutant of *Senecio pauperculus*, while the familiar ray-bearing type seemed completely absent. This plant was treated later by Fernald as *Senecio pauperculus* f. *verecundus*, but I feel very much inclined to give it specific rank as I did in the parallel case of *Senecio Rollandii*. Rosettes of

Fig. 5. Shore-line on the south side of Ile du Havre de Mingan (Mingania) showing adjacent colonies of *Senecio Rollandii* (left) and of *Senecio pseudo-Arnica* (right), just above the zone of *Elymus arenarius* var. *villosus*. (Photo Marie-Victorin).

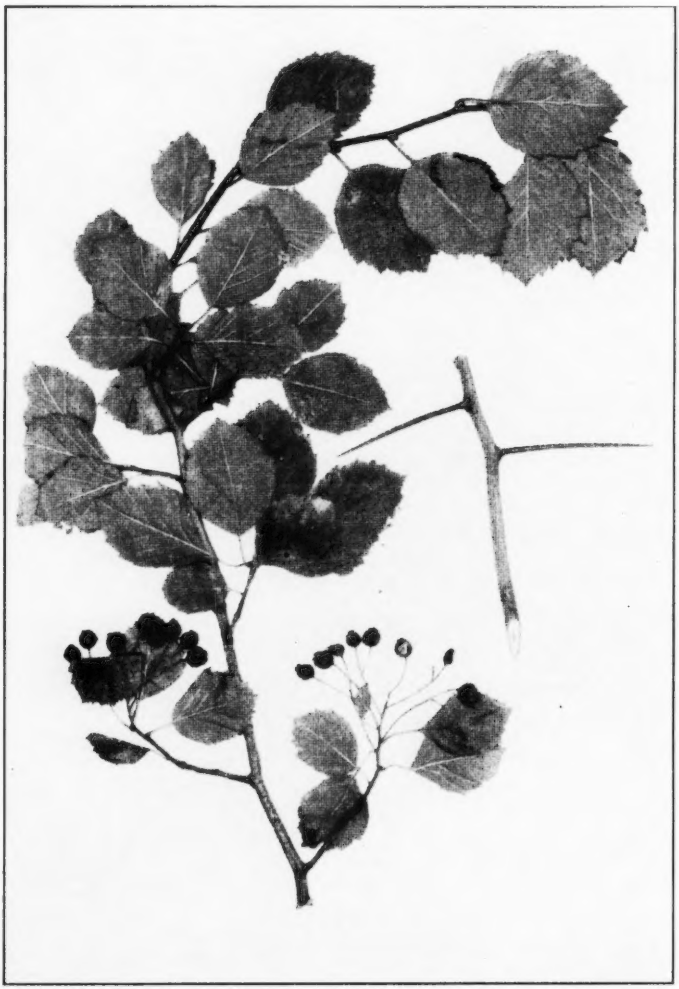

Fig. 6. *Crataegus Victorinii*, a St. Lawrence Valley endemic of post-glacial origin, restricted to the Montreal district.

Erigeron compositus brought from the Gaspé cliffs to the Montreal Botanical Garden in 1936 gave rise to the conventional slender ray-bearing type of the species, but also to several discoid and more robust mutants.

It is immaterial whether the orthodox taxonomist will treat discoid mutants in the Compositae as species, or discard them as trouble-makers, "forms" or monstrosities. There are no such things as monsters because there are no effects without cause. Michel Montaigne anticipating modern biological

Fig. 7. Park-like Hawthorn formation in the Indian Reserve of Caughnawaga, near Montreal (*Crataegus rotundifolia, C. Holmesiana, C. flabellata, C. canadensis, C. submollis, C. Jackii*, etc.) incidentally showing the effect of grazing. (Photo Marie-Victorin).

thought declares that *"les monstres ne le sont pas à Dieu."* The main point is that these mutants bring something new to the living world, and reproduce their kind, as is evident from a fair number of instances.

Another illustration of discontinuous evolution is found in the behavior of American Hawthorns.

Fig. 6 shows *Crataegus Victorinii*, a well-defined endemic of the Montreal district, and which has seemingly originated there. *Crataegus suborbiculata, Crataegus Jackii, Crataegus Brunetiana, Crataegus laurentiana* and a host of other species of the St. Lawrence valley seem to be likewise extremely localized and to have originated through the same process, whatever this process may have been.

I am well aware, from long field experience, of the biological implications of Crataegi. What is the real value of the multitude of species that have been described? And, when all is said, what is a species? But one thing can be said so far now: the different species of a given locality, if studied at flowering time are much better characterized and far more easily recognized

than those of *Epilobium, Aster, Antennaria, Rubus, Carex, Poa,* and other critical polymorphous genera.

The Hawthorns of northeastern America seem to be for the most part very young species. They are not forest types, but rather very exclusive heliotypes, plants of the open, invaders of neglected land, preferably calcareous (Fig. 7). Their more obvious response to this habitat is the abundant production of spines, simple on the branches, but very often compound on the main stems.

Very striking is the similarity of the *Crataegus* problem in northeastern America with the *Acacia* problem of the African table-lands. The N' Gong upland plains of Kenya in equatorial Africa may be taken as a fair sample of the Acacia country (Fig. 8). We have again the open, dry land, here occu-

Fig. 8. A bird's eye view of N'Gong Plains, in Kenya, Central Africa, an extensive grassy table-land occupied by a park-like association of thorny, mostly flat-topped Acacias (*Acacia giraffae, A. horrida,* etc.). (Photo Marie-Victorin).

pied by millions of small or middle-sized flat-topped *Acacia (A. giraffae, A. horrida,* etc.), generally well provided with spines. It is the alluring typical big game country with the herds of giraffes feeding on the tree-tops. The general picture suggests those venerable Lamarckian days when naive biologists wondered whether the giraffe's neck had stretched to get to the level, or whether the Acacias had become flat-topped as a fixed hereditary response to grazing! . . . But the interesting thing is, that the African Acacias, and the American Crataegi, under similar stimulating ecological conditions, have shown a similar power to produce an enormous number of species, or forms (Fig. 9).

Before the advent of the white man, the whole of the St. Lawrence valley was heavily forested, and outside of marshes and bogs, was almost entirely devoid of natural prairies. The dense and continuous coniferous or mixed forest precluded any important growth of Hawthorn colonies, save sparse individuals scattered along streams, a condition still prevalent on the northern

boundary of the genus: the Témiscamingue-Abitibi district, Lake St. John, the rivers of Anticosti and Gaspé.

Rapid deforestation in the St. Lawrence valley, and the tributary valleys of Lake Champlain and of the Ottawa River, created ecological depressions that the shade-loving herbaceous or shrubby elements of the near-by forest could not occupy. The Prairies of the Mississippi valley were too far away to send out heliophile invaders. It so happened that, perforce, the ecological vacuum was filled by European herbaceous plants brought surreptitiously by the French settlers with seeds, the wool of sheep, and the military forage supplies unloaded from ships. But the local flora had a few woody heliophytes, to this moment strictly confined to river-banks, and ecologically equipped to invade pasture lands and the waste spaces about villages and towns. This seems to have been the story of the development of *Crataegus* in the St. Lawrence valley, and indeed, over all northeastern America.

At the present period, the great Hawthorn populations, as could be expected, are located mainly near the older settlements of the country: Quebec, Montreal, Toronto, Rochester, the sites of ancient Indian villages (Caughnawaga), of early Hudson Bay forts (Fort Témiscamingue, etc.).

It seems safe to assume that the astonishing development of the genus in northeastern America, and particularly in the St. Lawrence valley, is an immediate biological response to the ecological disturbance or reduced compression brought about by deforestation and settling of the land.

The fact that, in the St. Lawrence valley, very recently freed from the Wisconsin ice and emerged from the Champlain Sea waters, — and only yesterday rendered available to Crataegi through deforestation and settlement, — the fact that we have here a good number of strictly endemic species, points

Fig. 9. Typical flat-topped Acacias of the N'Gong Plains, Kenya, Central Africa, an ecological case similar to that of the American Crataegi. (Photo Marie-Victorin).

to the conclusion that the migration and multiplication of forms must have taken place during the short colonial period.

We think we know the paths of migrations, which, mainly during historical times, have favored the wide distribution of the Hawthorns in the St. Lawrence valley. The center of dispersal seems to have been the temperate portion of the eastern United States, from which, following different lines, they have migrated over the entire continent, paving their way as they went with new forms.

Inasmuch as the first idea, and the pioneer work on discontinuous evolution, were based on *Oenothera* by Hugo de Vries and numerous workers along the same line, it is impossible to leave this subject without dealing with the *Oenothera* problem in northeastern America, and particularly in Quebec.

The botanists of the last half century had conveniently and conservatively dumped the Oenotherae of eastern Canada into two vaguely defined specific entities: *O. biennis* (for the inland plant) and *O. muricata* (for the coastal plant). We now know much more about them through field inquiries made by the author, and by critical cultures and cytological studies by Prof. R. R. Gates. It seems that we are dealing here with an intricate group of types, or micromorphs, most of them very local, originating or having originated through hybridism or mutation.

True *O. biennis,* according to Gates, is a Linnaean type of unknown American origin, already naturalized on the sand-dunes of Holland in 1614. This type, probably a local endemic that happened to make the hop between Dutch America and Europe, does not seem to have been collected or studied in America. The situation is almost the same for *O. muricata:* most, if not all, of the northeastern material referred to that species is something else.

For some reason or other, the St. Lawrence Valley happens to be exceptionally rich in forms of *Oenothera.* Looking for reasons, one thinks of the abundance of sands and loose soils about the Great Lakes, and in the alluvial section of the St. Lawrence River from Montreal to Lake St. Peter; to the loose calcareous debris at the base of the Gaspé cliffs. On these shifting, warm, dry, air-filled, well-lighted loose soils, shunned by most vascular plants, *Oenothera* has seemingly found its optimum conditions, and developed during post-pleistocene times many local species, or at least interesting micromorphs. Already milestones have been established in this study. The commonest plant in the St. Lawrence valley from Toronto to below Quebec city, seems to be *O. Victorinii,* related to *O. pycnocarpa,* a wide-spread plant in New York State. *O. Victorinii* is definite enough, but undoubtedly a dynamic center of variation. Gates has now referred to *O. ammophiloides* and its varieties, a part at least of the dominant sturdy glandular and large-flowered plants of the Gaspé cliff-bases, but there is material here also of several purely endemic forms to be described when better known. But the richest *Oenothera* territory in Quebec and possibly in the whole of northeastern America, is perhaps the section of the fresh-water tidal shore of the St. Lawrence river in the vicinity

of the Island of Orleans, Cape Tourmente and St. Vallier (mouth of Boyer River) (Fig. 10).

This district was already famous for its estuarine endemics, of course of post-glacial origin: *Gentiana Victorinii, Epilobium ecomosum, Bidens frondosa* var. *anomala,* etc. In a previous paper I have ventured to explain the formation of these endemics within the short span of the post-pleistocene, by an acceleration of the machinery of evolution due to peculiar factors involved in the intercotidal fresh-water habitat: double daily cycle of emersion and immersion, diminished competition, efficient devices for seed dispersal, etc.

It seems that, although not being intercodidal types, — Oenotherae planting their rosettes at the top of the gravel-spit or beyond, but always out of the reach of the tide, — these plants have benefited in a large measure of some of the stimulating estuarine conditions of the lower St. Lawrence. Nowhere else in eastern Canada, can such a variety and abundance in *Oenothera* be seen: *O. leucophylla, O. laevigata* var. *similis, O. laevigata* var.*rubripunctata,*

Fig. 10. Mouth of River Boyer, St. Vallier, Que., where at the top of the gravel-spit thrive *Oenothera leucophylla, O. laevigata* var. *similis, O. laevigata* var. *rubripunctata, O. biformiflora, O. biformiflora* var. *cruciata, O. Victorinii* var. *intermedia,* and other types of the same genus. (Photo Marie-Victorin).

O. biformiflora, O. biformiflora var. *cruciata, O. Victorinii* var. *intermedia, O. angustissima* var. *quebecensis, O. parva,* and others to be unraveled. Some of the species such as the large, shining and often almost glabrous *O. angustissima* var. *quebecensis,* and the small narrow-leaved *O. parva,* are remarkably well-defined (Fig. 11). Other scientific entities that have been described are also striking, but perhaps less secure.

Other districts, such as Lake St. John, the St. Maurice River lower valley, are also rich in puzzling forms, and would deserve careful study. In the Lake St. John country, we once had a thrilling experience. Hurrying to Mistassini one night after a strenuous field day, our attention was summoned by an

abandoned sandy field, fully occupied by *Oenothera*. In this northern country, summer days are long, and though it was past eight o'clock, the thousands of fully expanded primrose flowers presented a great sight and could be photographed. But the real thrill for the botanist was more in the astounding multiformity than in the mass beauty of the fading landscape. At least five different plants were there, largely grouped in pure colonies. There were groups of pale, eglandular plants, and groups of large, glandular and purple-tinged individuals; colonies with straight inflorescences and others with all shafts characteristically bent in one direction. Outside of that field the *Oenothera* were

Fig. 11. A pure colony of *Oenothera parva*, an endemic of the estuarine district of the Lower St. Lawrence. (Photo Marie-Victorin).

neither particularly abundant nor varied. Whence had all these come? Had they come there already differentiated from seeds ripened far away? Or did differentiation take place here in the course of a few short years?

Some botanists refuse to admit the multiplicity of the northeastern *Oenothera* on the ground that several forms are often found intermingled at the same place, and they ascribe this diversity to a wide-range fluctuation in a highly plastic group. But long field experience, with much attention given to these problems, shows that *Oenothera* populations, although sometimes exhibiting several intermingled forms, are very often remarkably pure, so much so that there is no hesitation to collect many specimens under the same number. Such is the case for instance with *O. parva* on the lower St. Lawrence and with *O. parviflora* on the sands of Lake St. John. *O. angustissima* var. *quebecensis* of Cape Tourmente is also unmistakable. The case of *Oenothera* parallels that of *Crataegus*. It is not rare, in the Montreal district, to see in the same neglected pasture, a good half-dozen Hawthorn species, perfectly distinct in May-June when floral characters are available.

I agree with Gates "that the activities of man during the last three cen-

turies in eastern Canada have given opportunity for their (Oenotherae) spread which did not exist when the country was mainly forested. The clearing of forests, cultivation and other soil disturbances by man have probably led to collisions between forms which were formerly isolated from each other. Although natural crossing is apparently unusual among the forms, yet it does occur. Owing to the catenations, such hybrids will breed true and will constitute in some cases new species or types generally intermediate between the parents."

To sum up, although the matter is as yet much involved, I think we can place *Oenothera* side by side with *Crataegus* as another wholesale case of discontinuous evolution.

All this suggests a very important and rather unexpected generalization: that under favorable circumstances, a period of two or three hundred years is sufficient to produce, in some genera at least, by mutation or otherwise, a marvelous outburst of species, or at any rate, of recognizable forms.

So much for these definite traces of discontinuous evolution.

As a general rule, such biological advances or regressions whose relation with the previous static condition is obscure, are actually referred to a more traditional mode of evolution which we consider, or at least call, continuous, perhaps simply because the number and affinity of the terms in line conceal their discontinuity.

We are thus led to study another series of facts illustrating the apparently continuous changes which have affected vegetation since its first appearance on the planet Earth.

There is such a thing as Plant Sociology. Plants behave amazingly like human beings. They are born, they live, they die. They associate for common good such as the myriads of individuals of *Betula populifolia* that spring on our abandoned fields. Very often different species come in contact and compete for ground, as e.g. when the Conifers invade the Birch formation. Generally, having competed long enough, one foe subdues the other, or they both agree to differ, and a climax, which is essentially an equilibrium. is reached.

Aggregation and association are, as a rule, beneficial to most species. Isolation, on the other hand, is a two-edged sword. Although instrumental in bringing about evolutionary advances, it often also leads to regression and extinction.

It should be relatively easy to reduce to cases of isolation the bulk of the species constituting what I have ventured to call the allogenous flora of easttern Canada. Although the matter is much more involved, it will be sufficient to study here two major agencies of plant isolation and extinction that have acted upon the Canadian flora.

A great event in the recent geological history of North America was the

gradual disappearance during Tertiary times of the North Atlantic land-bridge which, bordered to the south by the old Thetys sea, had linked America with Europe since Cambrian times (Fig. 12).

The sinking or drifting of the land must have been gradual, but when completed, the cold currents rushed southward, wind and insects could no longer bring about cross-pollination between plants of the now widely separate areas, and in general, ecological conditions became more and more different from one side of the Atlantic to the other.

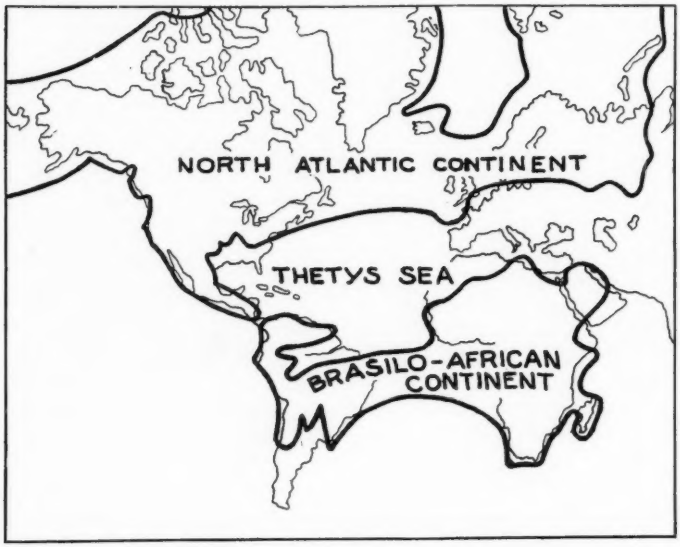

Fig. 12. Continental land-bridge over the North Atlantic Ocean during Tertiary times (Eocene).

These conditions brought about the disruption, divergence and independent evolution of the floras of northeastern America and northwestern Europe, up to this moment remarkably similar, owing to land continuity and uniform climate.

Thus we note the extinction in Europe of very remarkable present-day American trees such as the White Pine *(Pinus Strobus)*, the Tulip-tree *(Liriodendron tulipifera)*, the Bald Cypress *(Taxodium distichum)*, the Black Walnut *(Juglans nigra)*, the Hickory *(Carya alba)*, the Hemlock *(Tsuga canadensis)*, the Red Maple *(Acer rubrum)*. Very typical in this respect is the general distribution of the genus *Tsuga* in the northern hemisphere, with its present four widely separated areas, and the sites of Central Europe where Tertiary remains of our own eastern American Hemlock have been found.

On the other hand, America loses interesting elements such as the Water Chestnut *(Trapa natans)*. Other present-day European or Greenland plants such as *Phyllitis Scolopendrium, Atriplex maritima, Sparganium glomeratum, Habenaria albida, Polygonum acadiense, Carex Hostiana, Hieracium groenlandicum* are extremely localized and sometimes on the verge of extinction on the American side of the Atlantic.

This group of common European plants now almost extinct here, and holding their own only in rare spots around the Gulf of St. Lawrence, is perhaps best illustrated by the geographical record of a rare Sedge, *Carex Hostiana,* named after a famous student of grass plants, Nicholas Thomas Host. Years of painstaking exploration have revealed a peculiar local distribution: along the coast of western Newfoundland and southern Anticosti, suggesting a former continuous shore-line or continental shelf (Fig. 13).

But the general distribution (Fig. 14) is even of greater interest, for it tells a wonderful tale of former continuity and confirms in its own way the youthful character of the northern Atlantic Ocean. This tale of continuity can also be told *vice versa,* since common American plants are known to persist as relics in Scandinavia or on the Baltic *(Botrychium virginianum, Stellaria longipes, Montia lamprosperma, Carex marina,* etc.), in the British Isles *(Sisyrinchium angustifolium, Spiranthes Romanzoffiana, Eriocaulon septangulare, Juncus macer)* and elsewhere *(Naias flexilis, Galium trifidum, Spartina alterniflora, Spartina patens,* etc.)

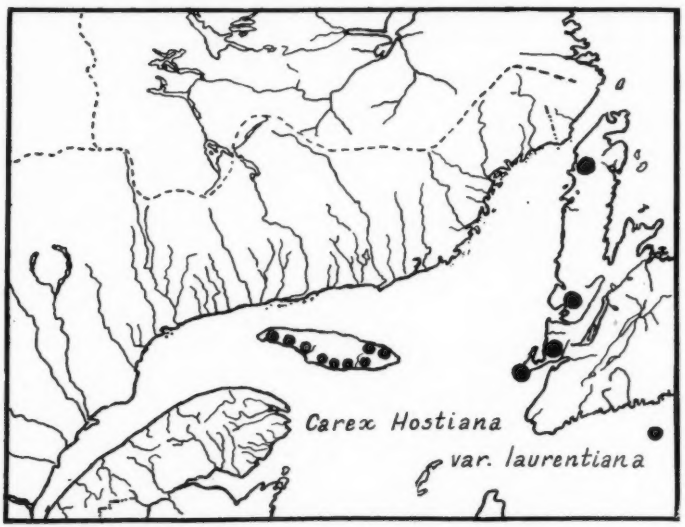

Fig. 13. Local distribution on the Gulf of St. Lawrence of *Carex Hostiana* var. *laurentiana,* suggesting a former continuous shore-line.

It should be stated at this point that though a great number of woody and herbaceous species disappeared on one or the other sides of the Atlantic following the separation of the two continents, most of the tree genera survived. Their species, however, gradually modified by long isolation, have come to diverge in such a way that, in most cases, the American tree can no longer be regarded as conspecific with the European.

It is of importance to note that in the present-day flora, northeastern America and northwestern Europe, although having in the main the same characteristic tree types, have not a single species in common, the only debatable exception being the Juniper *(Juniperus communis)*, which however, in the whole of North America assumes a habit (var. *depressa*, var. *megistocarpa*, etc.) quite different from that of the familiar upright European form.

But the same evolutionary factor, isolation, acting in roughly similar con-

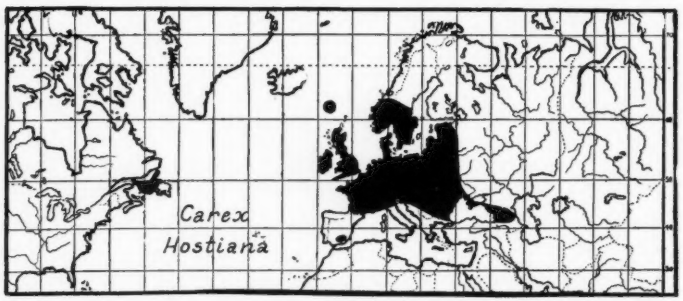

Fig. 14. Generalized range of *Carex Hostiana* (sensu amplo) showing the persistence of a small disrupted area about the Gulf of St. Lawrence, a remarkable condition correlated with the disappearance of the North Atlantic land-bridge.

ditions of environment on both sides of the Atlantic, was bound to produce parallel specific differences. Such is actually the case. For very many common American trees and shrubs, particularly of the Alleghanian region, there is a parent species abroad, the two forming an evident and closely related pair. The relationship can easily be demonstrated for the Beeches, the Birches, some of the Pines, the Hornbeams, the Elms, etc.

Indeed the Iron-wood *(Ostrya virginiana)* is but the American phase of *Ostrya carpinifolia* of Europe. The divergence is actually so slight that the two might be considered as conspecific, according to certain standards. The Slippery Elm *(Ulmus fulva)* of America forms a pair with the English Elm *(Ulmus campestris)*, and our magnificent American Elm *(Ulmus americana)* is but the New World improved replica of *Ulmus pedunculata* of Europe. Pubescence only differentiates members of striking pairs of species, such as our *Sorbus americana* and *Sorbus Aucuparia* of Europe.

In the Conifer series a like relation can perhaps be established between the Jack Pine *(Pinus Banksiana)* and the Scotch Pine *(Pinus sylvestris)*, as well

as between our Laurentian White Pine *(Pinus Strobus)* and the Balkan Pine *(Pinus Peuce)*.

Numerous notable pairs of species, telling the same story of divergent micro-evolution, could be listed among shrubs and herbaceous plants such as: *Viburnum Lantana* and *Viburnum lantanoides, Viburnum Opulus* and *Viburnum trifidum, Sambucus racemosa* and *Sambucus pubens, Lonicera coerulea* and *Lonicera villosa, Oxalis Acetosella* and *Oxalis montana, Circaea lutetiana*

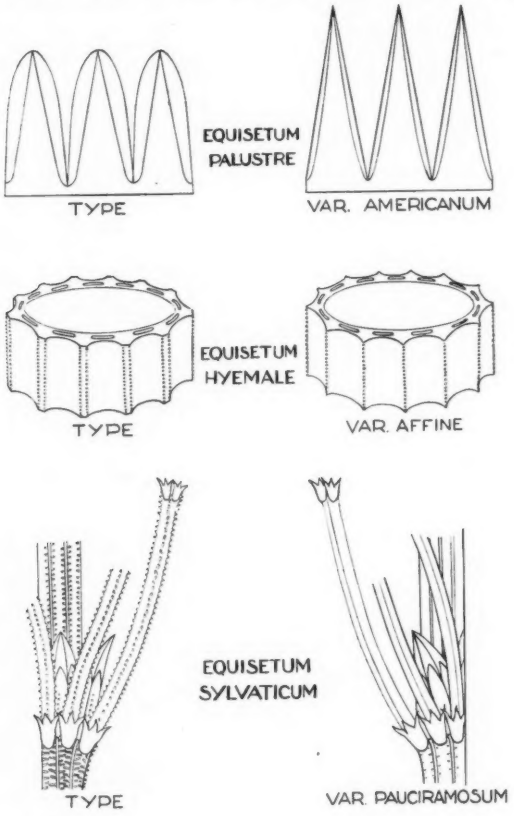

Fig. 15. Divergent tendencies of three species of *Equisetum*, each of which occurs on both sides of the North Atlantic Ocean. The figures on the left outline details of the Old World Linnaean types. The figures on the right show the corresponding structures in the American representatives. (Marcel Cailloux, del.)

and *Circaea latifolia, Vallisneria spiralis* and *Vallisneria americana, Maianthemum bifolium* and *Maianthemum canadense, Hepatica nobilis* and *Hepatica americana, Nuphar luteus* and *Nuphar variegatus, Polygonum amphibium* and *Polygonum natans, Rumex Hydrolapathum* and *Rumex Britannica, Polypodium vulgare* and *Polypodium virginianum, Athyrium Filix-femina* and *Athyrium angustum, Lycopodium complanatum* and *Lycopodium flabelliforme,* etc.

We can go a step farther. Almost any careful intra-specific analysis of admittedly circumboreal species confirms this bicentric micro-evolutionary trend. For instance isolation has not left untouched the common Horsetails of the northern hemisphere. *Equisetum sylvaticum* of Europe has the base of the branches scabrous, while it is essentially glabrous in most North American plants. The teeth of European *E. palustre* and its American representative show an average difference in length and margin. The endemic tendency of the American *E. hyemale (E. hyemale* var. *affine)* towards a single row of tubercles on the stem ridges, has long been known and acknowledged (Fig. 15).

It seems that this bicentric micro-evolution has been so general that we may well accept the phytogeographical law proposed by Fernald: "Species which in America are confined chiefly to the Alleghanian region will be found to differ in very fundamental characters from their nearest allies of continental Europe."

The gradual disappearance of the North Atlantic land-bridge and the assumption that the process seems to have progressed from the south northward, offers a satisfactory explanation for a certain number of surprising floristic facts. For instance, the Heaths (*Erica* spp.) may have missed America by a few million years because, travelling a long way from their South African center of dispersal, they did not reach northern Europe in time to "use the bridge."

Only because the breaking off of the hyperboreal land-masses is so recent, can the holarctic flora be so homogeneous. As we go south, neo-paleoboreal differentiation increases, as it were, in concentric rings, and indeed also local differentiation. In a very pertinent paper on Quebec *Astragalus,* Rousseau has pointed out a striking example of biological segregation within the group of *A. alpinus* (sensu amplo), seemingly by successive north-south migratory waves and ultimate entrenchments in isolated river basins. The varieties of *Tanacetum huronense* (var. *johannense,* var. *bifarium)* described by Fernald point to the same series of phenomena.

A similar process of differentiation, but mainly in a west to east direction, characterizes the whole group of crossopetalous Gentians. They seem to have radiated eastward from a Cordilleran center of dispersal, losing momentum as they went! Of the six Cordilleran species: *Gentiana ventricosa, G. Macounii, G. tonsa, G. elegans, G. simplex, G. barbellata,* only the first two reach Hudson Bay where they contact the western limit of *G. nesophila.* Then appears the midcontinental *G. procera* and the eastern *G. crinita;* then the endemic northeastern *G. Victorinii* and *G. gaspensis,* and again on the Gulf of St.

Lawrence the bicentric *G. nesophila,* and finally in Greenland and northern Europe *G. serrata.* What does this fascinating story of distribution really mean? (Fig. 16).

But another great geological event, bound to have a decisive bearing on the future evolution of the Canadian flora is now at hand. At the close of the Tertiary, the flora and fauna of boreal America are again submitted to the great ordeal of glaciation, a mass phenomenon which preceding eras had also witnessed as the Ordovician tillites of eastern Quebec clearly show.

The causes and *modus operandi* of the Great Glaciation do not concern us here. The subject has received a very able treatment in the hands of notable geologists, particularly Professor A. P. Coleman of Toronto and W. B. Wright in England. It is enough to recall that at this period, an immense sheet of ice, endowed with tremendous mechanical force overran everything in its advance, covering at times two million square miles of territory, stretching from Labrador to Alaska, descending as far as Montana, with a wedge into the valleys of Mississippi and Ohio, and reaching the Atlantic in northern New Jersey. This sheet of ice seems to have radiated from three centers: Labradorian, Keewatinian and Cordilleran (Fig. 17).

In the course of the round million of years of this long Ice Age, there were movements of advance and retreat, with interglacial periods between. During these recurrent interludes the climate became again temperate, and the vegetation, previously pushed to the south, returned to its former home.

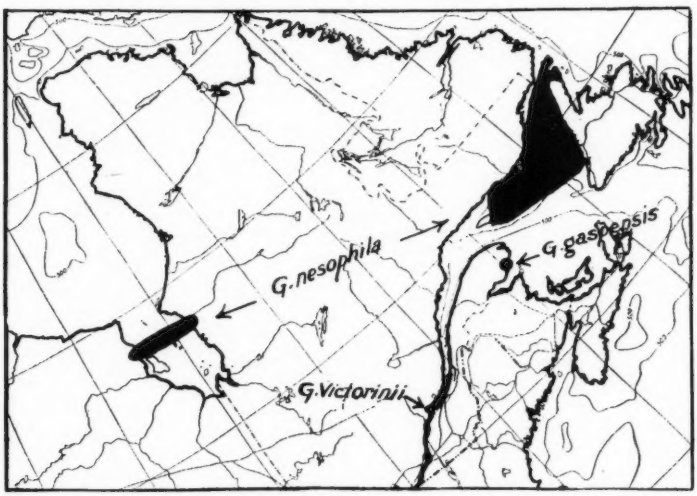

Fig. 16. Distribution of a group of endemic crossopetalous Gentians of northeastern America, with special reference to the bicentric range of *G. nesophila.*

Thus we have the momentous picture of "great hosts of plants oscillating between the poles and the equator, their ranks thinning by the friction attendant on their movement, which has extinguished perhaps whole battalions" (Thiselton-Dyer).

The penultimate return of the ice, at the so-called Jerseyan period, seems to have covered the whole of the St. Lawrence valley, and to have destroyed all vegetation therein.

Then opened an interglacial period that may have lasted sixty or eighty thousand years. We know something of the flora of this last interglacial epoch, from the scanty fossil remains which have been found on the Moose River, near James Bay; in Toronto at Scarboro Bluffs and in the Valley of the Don River (Fig. 18). The Toronto deposits have furnished forty-two species of plants indicating a climate equivalent to that of present-day Pennsylvania. Some of these plants such as Sassafras *(Sassafras variifolia)* are still living a little farther south, others such as *Acer torontoniensis* and *Acer pleistocenicum* have become extinct (Fig. 19). *Acer pleistocenicum* may have been identical with the Norway Maple *(Acer platanoides)* planted in our parks and streets. Possibly a common tree in the St. Lawrence valley during the last interglacial period, it became extinct here but was preserved in northern Europe.

This much we know of the interglacial floras by the records of Toronto clays. But we think we know much more from living documents, from a relic

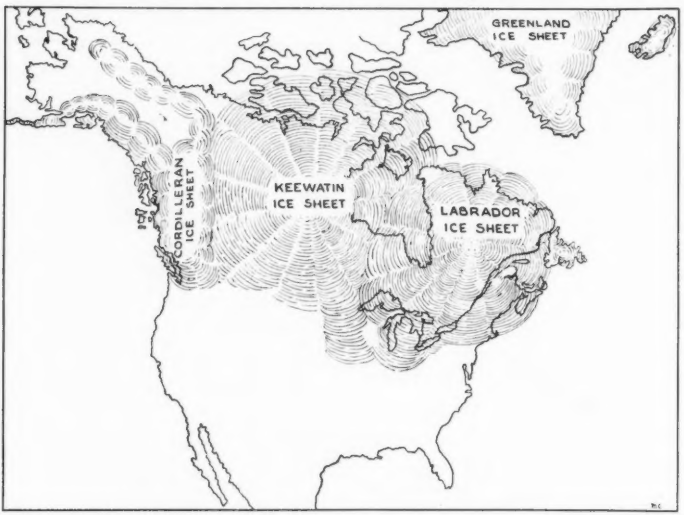

Fig. 17. Maximum extent of Glaciation in North America, with the several centers of radiation and the northeastern supposed nunataks, shown in detail in figure 20. (After A. P. Coleman and others).

flora that has persisted to this day about the Gulf of St. Lawrence to tell the story!

The last interglacial period draws to a close. The climate becomes once more very cold, again the ice rushes south, and we have the last or Wisconsin glacial period. The ice covers the country, but it now seems apparent from the work of Coleman and Alcock, supplemented by the work of a group of botanists inspired by Fernald, that this final offensive was not very severe in Eastern America, and that many high spots and possibly strips of the lowland were left untouched.

These high spots, these nunataks as they are now called from an Eskimo word, we visualize either as green oases or barren islands on the white horizons of this strange period. Were the nunataks lost in the expanse of this most

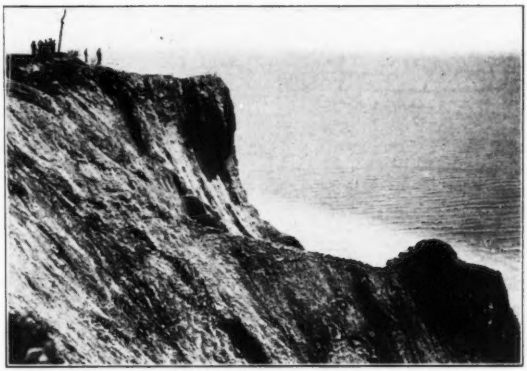

Fig. 18. Scarboro Bluffs (Toronto, Ont.), showing the enormous accumulation of glacial and interglacial deposits now battered by the waves of Lake Ontario. (Photo Marie-Victorin).

complete of deserts, absolutely deprived of life? They are supposed, — and here the relic theory comes in, — to have sheltered an interesting, though greatly impoverished flora, made up of sturdy species saved from the ice and bound to adapt themselves to a new and violently different environment.

Is this but an imaginative bit of paleo-phytogeography? How do we know all that? The botanists of the last 25 years have gradually discovered, listed and organized into an impressing factual body a rather large number of allogenous elements more or less interwoven with the fundamental flora of north-eastern America. The area where most of these allogenous elements are found coincides in the main with the non-glaciated lands of Wisconsin times. We are naturally led to infer that our living allogenous flora is a survivor of an important and now largely extinct flora cornered on the nunataks during the Wisconsin glaciation.

It is important to point out here that the elimination of the less plastic

forms of life, allowing room for the expansion of the more plastic and progressive forms, may have been one of the most efficient factors in the evolution of new species, and may have accelerated pre-existing evolutionary trends.

I have just hinted that the districts where the allogenous elements, endemic or epibiotic, are distributed, coincide so clearly with the districts which the

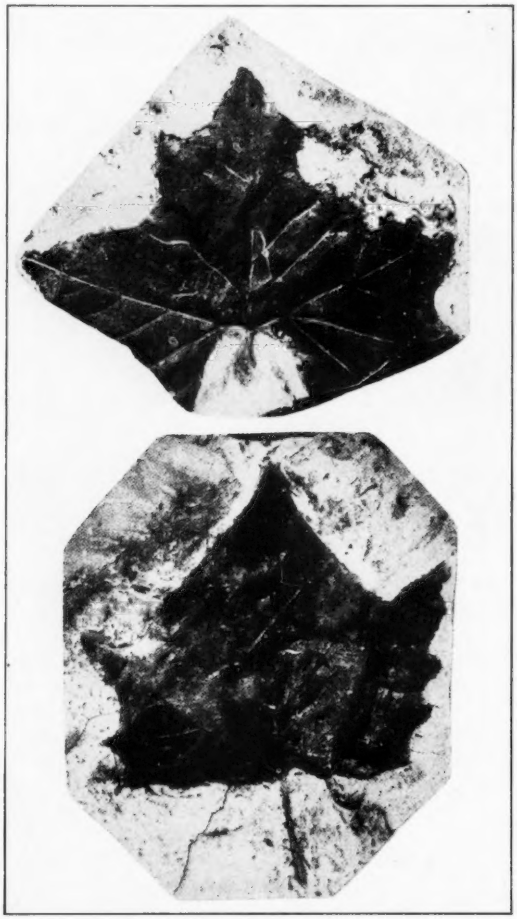

Fig. 19. *Acer torontoniensis* (above) and *Acer pleistocenicum* (below) two extinct Laurentian Maples of the last interglacial period. (After J. H. White and A. P. Coleman).

the geologists have successively and more or less reluctantly pronounced as unglaciated, that it was very natural to correlate the two. The idea gains momentum by the fact that a parallel condition exists in northwestern Europe. It is agreed amongst geologists, that the Great Baltic Glacier, nearly synchronous with the American Wisconsin, did not invade the northernmost borders of Norway, western Denmark, the Faroe Islands, and a portion of Iceland. Fernald has pointed out that at least one hundred species which are restricted in America to areas not covered by Wisconsin ice, occur likewise in Europe in areas which were not covered by the Baltic Glacier. Fair samples of this flora are *Epilobium latifolium, Lomatogonium rotatum, Polygonum acadiense, Atriplex maritima* and *Scirpus pumilus*. The last case is extremely demonstrative, *Scirpus pumilus* being known only by three stations on the extreme northern border of Norway left out by the Great Baltic Glacier.

Of course I know that linking thus the allogenous flora of northeastern America with glacial and interglacial phenomena is open to certain objections. When the theory was proposed and expounded by Fernald, almost twenty-five years ago, it became at once very popular among American botanists and was

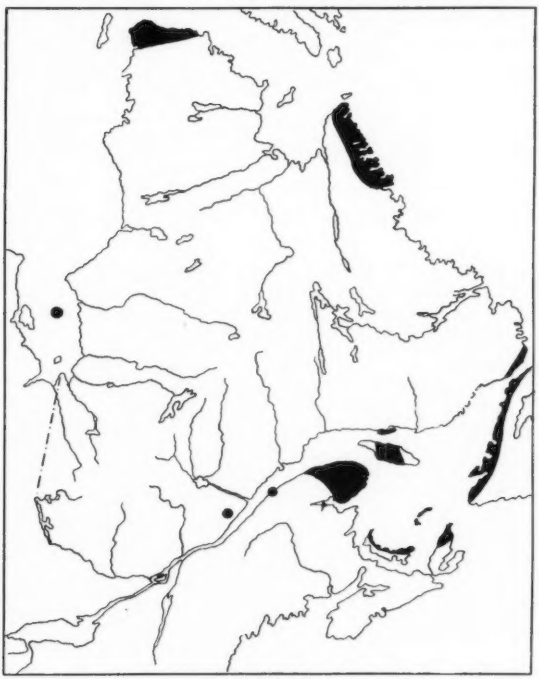

Fig. 20. The supposed nunataks (in solid black) of northeastern Canada.

supposed to cover and explain all the facts of endemism and isolation. But time has passed and data have accumulated. Doubts have been persistently expressed as to the absolute value of the theory. In my own work in the Mingania-Anticosti district, I have brought in line a number of facts that can not easily be reconciled with the strict nunatak explanation. But, for the sake of exposition, an imperfect order is no doubt better than none at all, so that for the time being, it seems preferable to retain the main lines of Fernald's hypothesis, notwithstanding its weak sides, which will be exposed further on.

We have then a number of regions, centering about the Gulf of St. Lawrence, that presumably did escape the sheet of ice of the Wisconsin period (Fig. 20).

The unglaciated districts were mainly the Torngat Mountains of Labrador, Western Newfoundland, the Magdalen Islands, certain parts of Cape Breton Island, the Shikshok Mountains and some cliffs of Gaspé, and certain small areas: Le Bic, Tourelle, St.-Urbain, Twin Islands, etc.

As an introduction to the topographical aspect of unglaciated regions, Mount Albert, of the Shikshok Mountains of Gaspé, is as good as any other. An impressive table-land, four thousand feet high, evidently a bit of the Cretaceous peneplain uplifted during Tertiary times; deep valleys; scanty vegetation; clear, icy brooks; herds of cariboos roaming the upland pastures.

Table-Top Mountain, also in the Shikshok range, is separated from Mount Albert by the deep valley of Sainte-Anne River. It is slightly higher than Mount Albert, and much more extensive. The surface consists of loose blocks of the underlying granitic rock, seldom showing any displacement. No striated surfaces and no boulder clays are found there. A quite typical unglaciated mountain top.

Fig. 21. Shikshok Mountains of Gaspé, seen from the summit of Mt. Albert. (Photo Marie-Victorin).

When one stands on the summit of Mount Albert, the Shikshoks roll before the eyes in huge endless waves (Fig. 21). It is a wild, rugged, unfriendly, soulless country, some parts of which are yet unmapped. But its flora has been for the last twenty-five years the lure of field botanists and plant-geographers in northeastern America. In fact, only a very small group of men, mostly geologists and botanists, can claim any knowledge of that country. Since every bit of exploration brings unexpected additions to the flora, I suspect that when this territory will be completely explored, the sharp contrast between the floristic catalogues of Eastern and Western America will be done with.

To the unglaciated areas now officially recognized as such by geologists must be added tentatively, and only from the testimony of its allogenous flora, a part at least of the limestone shelf, formerly running along the North Shore of the Gulf of St. Lawrence, and that can be termed an "avant-pays," a foreland.

This shelf has crumbled or sunk in the sea, leaving only Mingania (the Mingan Archipelago) and Anticosti, lands of mystery which, though probably glaciated during the Wisconsin, present the biological characteristics generally associated with unglaciated regions.

All these narrowly limited districts supposedly preserved, during the Wisconsin glaciation, a part of the vegetation which covered them during the preceding interglacial period. This vegetation seems to have had great affinities with the present Rocky Mountain flora, and, to a lesser degree, with the flora of subarctic and arctic Europe. It has been postulated that the interglacial flora ran uniform from the Rockies to the Atlantic and that the Wisconsin advance obliterated all vegetation between these two points, save in limited and isolated spots (Great Lakes, James Bay, Gulf of St. Lawrence), thereby cutting off these nunatak floras from the Rocky Mountain flora, and setting in action the evolutionary machine of geographical and biological isolation. But this interpretation probably needs closer critical study.

The whole supply of water vapor being imprisoned in Wisconsin Ice, the nunataks and the long belt bordering the ice-front were as is likely dry, barren, and steppe-like.

We can to day visualize these conditions in some parts of Mingania and Anticosti. Ile Nue, for instance, opposite Longue-Pointe de Mingan, is liable to impress the visiting botanist who bears this ancient history in mind. It is neither a sedge-grass semi-halophytic prairie, nor a bird-rock with its attendant nitrophilous flora. It is rather a slightly raised tundra with a weird row of erosion monoliths towering, — in Easter Island fashion, — all around the rim of the island. The tundra lies on flat, creviced limestone strata insuring a most efficient drainage which rules out tree growth and creates even in this damp climate intense xerophytism (Fig. 22).

Most woody plants of Ile Nue possess a powerful underground system, but their prostrate aerial parts crawl over Polytrichums and Cladonias. The

Fig. 22. The tundra-like vegetation of Ile Nue (Mingania), a very low shrubbery of various Ericaceae, with *Acer spicatum, Viburnum pauciflorum, Amelanchier Bartramiana, Salix cordifolia, Betula microphylla;* also characteristic allogenous herbaceous elements, such as *Cypripedium passerinum* var. *minganense, Draba minganensis,* and *Streptopus oreopolus.* (Photo Marie-Victorin).

association includes dwarfed *Cornus canadensis, Dryas integrifolia, Vaccinium Vitis-Idaea* var. *minus, Arctostaphylos Uva-Ursi* var. *coactilis, Arctostaphylos rubra* together with several puzzling forms of *Salix cordifolia.* Standing a little over these, in damp places, are *Viburnum pauciflorum,* the Cordilleran *Betula microphylla,* the northern *Amelanchier Bartramiana,* and a strange form of *Acer spicatum,* in leaf-shape similar to *A. rubrum.* But here, as almost everywhere in Mingania, obscure events in the biological sequence have left living traces, and we cannot but wonder at such unexpected plants as the claret-flowered *Streptopus oreopolus,* the enigmatic yellow *Draba minganensis,* and the Rocky Mountain *Cypripedium passerinum.*

As has already been intimated in a general way, such conditions as those prevalent on Ile Nue and other parts of Mingania-Anticosti eliminate certain species, clear the ground for others, and open new possibilities of adaptation and evolution. The two thousand mile ice-front we are visualizing in Wisconsin time, with its equable ecological conditions, may have been an important highway for the eastward migration of Cordilleran plants. But we will see later that this explanation of the occurrence of many of the so-called Cordilleran plants in the east is not the only one possible.

During hundreds of centuries, the ice surrounds the nunataks and this evolution goes on. With the final recession of the ice, the Laurentian Shield, left burdened with a heavy mantle of drift and with endless moraines, the St. Lawrence valley, and the whole of northeastern America are definitively colonized by an essentially young, aggressive, and uniform type of vegetation,

which finds its most perfect expression in the present flora of the Laurentide Mountains.

The leading botanical traits of this flora are its ecological diversity, its floristic uniformity and its lack of local endemics. Any hundred square miles repeat the plant units and the plant associations of the whole region (Fig 23).

And now we imagine the aggressive types of the so-called Canadian Spruce forest coming up north, striding over moraines and ice-polished slopes, surrounding the nunataks and invading those secluded rock-gardens of the past.

Fig. 23. A typical Laurentidian landscape, showing the "roches moutonnées" topography, large boulders, and the *Picea-Abies-Betula* association. (Photo Marie-Victorin).

Fig. 24. A beautiful stand of White Spruce *(Picea glauca)* at Percé, Gaspé Peninsula, Que. (Photo Marie-Victorin).

Indeed a great biological picture, this onward march, spread on the geological time-scale! In America at least, there was no frowning Macbeth on the wall to watch Birnam woods coming up to Dunsinane! But, nevertheless on and on came the "moving groves"!

First came those ever ready pioneers: the Black Spruce and the White Spruce (Figs. 24 and 25), and the Balsam Fir, and the Larch, and later the stately Pines. Then followed the Aspens and the Birches, the Alders and Viburnums, the Dogwoods and Vacciniums. And the Sugar Maple took possession of the well-drained moraines alongside the valleys, and the Hemlock

Fig. 25. A characteristic sample of the Black Spruce forest *(Picea mariana)*, Abitibi district, Que. (Photo Marie-Victorin).

Fig. 26. A Sugar Maple *(Acer saccharum)* grove, established on a well-drained moraine at St. Jérôme, Que., on the edge of the Laurentidian area. (Photo Marie-Victorin).

fought its way amongst deciduous trees (Figs. 26 and 27). Meanwhile had come the wiry Grasses and the coarse Sedges, the legions of Goldenrods and Asters, and hundreds after hundreds of herbaceous or shrubby plants urged on by the spirit of conquest, making of the whole country one great mass of greenery.

Fig. 27. Interior of a Sugar Maple *(Acer saccharum)* grove, on the edge of the Laurentidian area, showing the large boulders. (Photo Marie-Victorin).

Fig. 28. A morainic landscape, in the heart of the Laurentidian area, Charlevoix County, Que. (Photo Marie-Victorin).

Frère Cléonique-Joseph, in an unusually interesting paper, visualizes this re-invasion of the Canadian country as a combined effect of three definite conditions: low ecological pressure (or ecological depression) in the recently ice-freed territory, youthful character of the soil, and progressive improvement in climate. He also emphasizes, or rather demonstrates, the part played by the lakes in the accumulation, conservation, and organization of the actual Laurentian phytomosaic. Following the recession of the ice, the re occupation of the immense rejuvenated territory got under way at a rhythm which benefited of the unique ecological conditions of the time, and of the great difference of ecological pressure between the non-glaciated territory to the south teeming with life, and the still barren drift-covered area to the north.

The latter, owing to numberless moraines (Fig. 28) and glacial damming was dotted with innumerable lakes. These lakes, large or small, ripped the continuity of the marching coniferous or deciduous forest, and broke the

Fig. 29. Lake Ste. Anne, in the heart of Gaspé peninsula, showing a pure stand of *Abies balsamea*, an important element of the post-glacial Canadian forest. (Photo Marie-Victorin).

schematic structure of the great plant associations. In allowing unlimited overlapping of specific ranges, in providing convenient homes on the lake shores for a host of light-loving plants and for a multitude of hydrophytes, the great network of lake-and-stream system was instrumental in enriching the flora without altering its homogeneous character (Fig. 29).

At the present period, while the ice is perhaps still retreating to the north, the main forest groups keep in order of march. The northern conifer forest leads, impressive in its simplicity and its enduring likeness in all seasons, for there is no winter for the Spruce needle and for the Lichen on the bark. Four species *(Picea glauca, P. mariana, Abies balsamea, Betula papyrifera)* dominate this vast mossy forest floor, with their millions of millions of short-lived and small-sized individuals. South of this limit is developed a puzzling

and less simple forest group that can be called "Eastern Hemlock Region" (Nichols), where conifer areas, hardwood areas, and various mixtures of both, make a transition to the highly complex deciduous forest to the south, almost entirely made up of large-sized and long-lived broad-leaved trees.

If now we go back to the old species nesting on the nunataks, we picture that since forty-odd thousand years perhaps, they wage a losing fight against the sturdy northern conifers and their natural ecological associates.

It seems too much for them. Through ecological pressure or through the failure of some essential biological processes, intrinsic or extrinsic, the old species have already surrendered most of the ground. They are mostly very local, some of them extremely so, being confined to one mountain-top, sometimes to one definite crevice of a particular mountain, or to one secluded cove by the seashore.

How localized are now these alleged preglacial plants is well-known to all botanists who have done field-work in this part of the world. But this fact can be visualized mathematically by glancing at the calculations patiently made by Fernald in view of opposing the general application of Willis' "Age and Area" theory.

Fernald considers as members of the ancient flora of Gaspé "the species which to-day occur upon the unglaciated mountains above the 2000-foot level (the upper limit of general glaciation) and which are not in the arctic and subarctic regions to the north." The ranges of the indigenous plants of Gaspé peninsula were derived by Fernald from daily records during many seasons, of all plants seen or collected in every township, river system, lake and mountain area, by himself and his associates. Few floristical inventories have ever been so thorough. Below are some of the results. The "old" species show no tendency to occupy the whole length of the Gaspé lobe, although the mountain range forming the backbone of the peninsula would help them to do so. Their average longitudinal dispersion is 0.45% (as compared with 0.72% for the common "young" flora). In *Salix* the figure drops to a low of 0.29%, while in the Grasses a maximum of 0.54% is reached. The cold figures of course lend a mathematical certainty to the case, but they are even less impressive than the many individual cases when the known distribution is reduced to one, or very few definite and limited stations.

To-day, only the trained eye of the professional botanist can see that the nunataks, although seemingly continuous with the rest of the country, are still physiologically insular, that they are centers of endemism where, with the delicate instrument of morphological and cytological analysis, we can detect the flow and beat of organic evolution.

Such is the biological epic one can put up on the theme of the nunatak theory. Must we include this epic in the body of North American phytogeographical knowledge, or must we settle down to a less romantic genesis for the allogenous flora of northeastern America?

The local endemics or relics forming the bulk of the allogenous and seem-

ingly vanishing flora of northeastern America have received much study for the last thirty years in the hands of a group of United States and Canadian botanists. It is now time to introduce a number of these allogenous species. Their various peculiarities will, I hope, convey an abstract of the geological and biological problems involved.

Let us go back to Mount Albert. Ascending to the top, we alight on a level treeless serpentine tableland, about ten square miles. It is a kind of roofless Noah's ark preserving a host of preglacial plants.

Here again, the loose rocks, congeneric with the substratum, are characteristic of unglaciated spots, and the botanists can collect to their heart's content in these almost moon-like surroundings. Beyond the "Coulée des Neiges" snow fields often persist during the summer (Fig. 30). Although the place seems barren, a recital of the flora under view would include a rich list of alpine and arctic plants, of relics and local endemics.

Fig. 30. Unglaciated top of Mt. Albert, showing loose serpentine rocks amongst which grow *Adiantum pedatum* var. *a'euticum*, *Polystichum mohrioides* var. *scopulinum*, *Pellaea densa*, *Festuca scabrella*, etc. In the background a snow field photographed on August 9th, 1923. (Photo Marie-Victorin).

An illustration is *Polystichum mohrioides* var. *scopulinum*, a small fern rooted in the crevices of serpentine rocks. In shape, the fronds resemble those of the Holly-fern of our lowland woods *(Polystichum acrostichoides)*, but they are much smaller. The great interest of the plant lies in its almost entirely Cordilleran distribution, Mount Albert being the only station for it in eastern America. *Adiantum pedatum* var. *aleuticum*, *Pellaea densa* and *Festuca scabrella*, the three of them also typical Cordilleran serpentine plants, are other characteristic elements which however occur also at very low altitude in the serpentine belt of southern Quebec.

Nearby can be seen in full flower dense tufts of two Sandworts: *Arenaria*

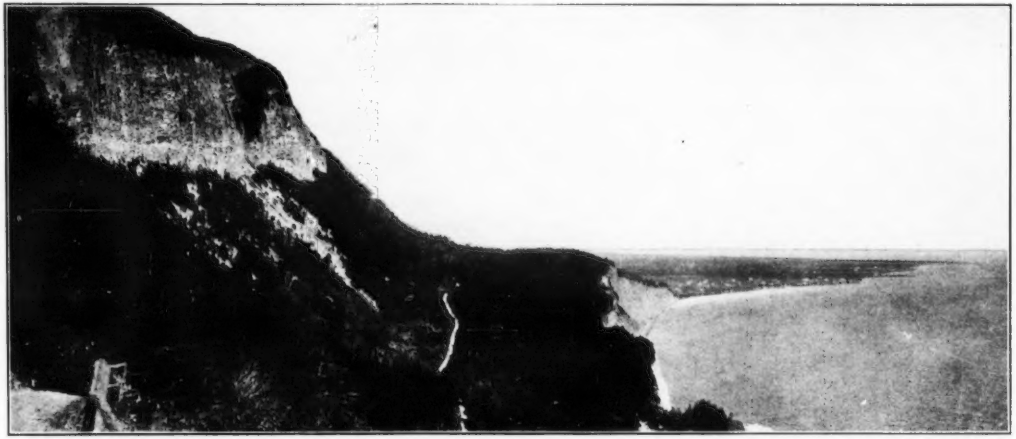

Fig. 31. Wild cliffs of Cap des Rosiers, Gaspé Peninsula. In crevices at the top of the vertical rock exposure, *Erigeron compositus* was found for the first time in eastern America (1923). On the limestone shingle at the base of the upper wall grow such local relics as *Arnica chionopappa, Dryas Drummondii* and *Polystichum Lonchitis*, and nearly at the sea-level, by the wave-cut seashore, *Erysimum coarctatum, Solidago multiradiata* and *Saxifraga cernua*. (Photo Marie-Victorin).

sajanensis of the arctic regions, and *Arenaria marcescens*, endemic on Mount Albert; *Ranunculus Allenii, Statice labradoica, Viscaria alpina, Rhododendron lapponicum* and a wonderful display of creeping Willows: *Salix brachycarpa, Salix fuscescens, Salix anglorum, Salix Uva-Ursi*, etc.

And now we cross the valley of River Sainte-Anne, fifteen miles as the crow flies, and reach Table-top, an extensive outcrop of granitic rock. In the alpine meadows a botanist can get the endemic *Agoseris gaspensis, Petasites vitifolius, Draba Allenii, Ranunculus Allenii, Orobanche terrae-novae, Salix argyrocarpa, Salix planifolia*, hyperboreal ericaceous plants, *Lycopodium alpinum*, and other arctic-alpine things.

Now let us leave the rugged interior of Gaspé and visit some of the coastal cliffs. We are here at Cap des Rosiers, a most wild and impressive piece of landscape (Fig. 31). Among the loose limestone debris at the base of the mountain by the sea, *Draba Peasei, Arnica chionopappa, Erysimum coarctatum, Saxifraga cernua* and *Solidago multiradiata* are scattered, while in the crevices near the bleak top of the bold cliff-wall a beautiful little relic Fleabane is apparently fighting present-day odds. This plant, *Erigeron compositus* var. *multifidus*, a well-known Greenland and Rocky Mountain species, blooms very

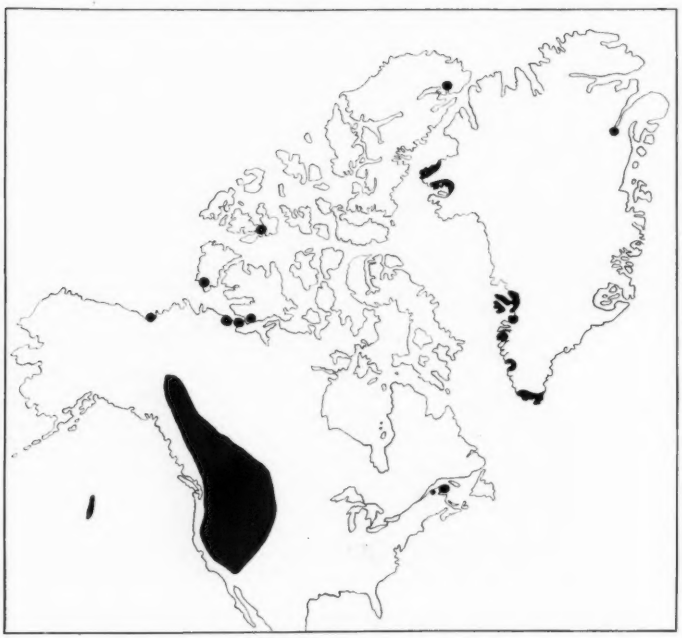

Fig. 32. General distribution of *Erigeron compositus*.

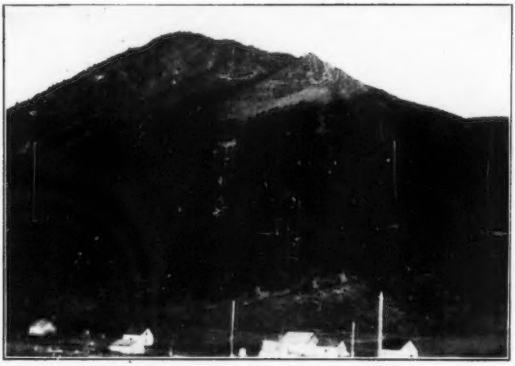

Fig. 33. The denuded top of Mont St. Pierre, Gaspé peninsula, is a garden of relics, mostly Cordilleran: *Erigeron compositus*, *Astragalus scrupulicola*, *Oxytropis gaspensis*, *Draba lanceolata*, *Elaeagnus argentea*, etc. (Photo Marie-Victorin).

Fig. 34. Anse Pleureuse, Gaspé peninsula. In the loose limestone shingle of the talus slope, *Oxytropis foliolosa* and *Gentiana propinqua* have their only known stations south of Labrador. (Photo Marie-Victorin).

early, and in summer only the tiny dissected foliage is to be seen. For this reason it had escaped the attention of botanists until recently. It is now recorded also at Percé, Mont St. Pierre and Le Bic. The distribution map illustrates perfectly the relic character of this Nearctic-Cordilleran gem of our northeastern flora (Fig. 32).

Not very far from Cap des Rosiers, some fifty miles up the St. Lawrence, the botanist beholds an impressive suite of high cliffs with somewhat denuded slopes, and accumulated limestone débris where they plunge into the sea: Ruisseau Sorel, Rivière à Claude, Mont St.-Pierre, Mont-Louis and Anse

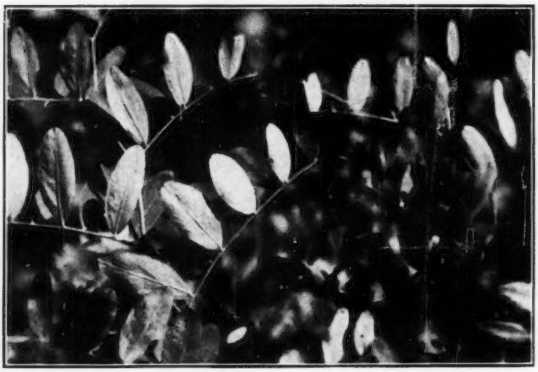

Fig. 35. *Lathyrus nevadensis*, a Cordilleran relic, known only (in the sterile condition) from the gravel flats of Burton's Gully, on Little Cascapedia River, where it grows side by side with *Dryas Drummondii*. (Photo Marie-Victorin).

Pleureuse, etc. (Fig. 33). Mont St.-Pierre has famous endemics and epibiotes: *Erigeron compositus* var. *multifidus, Oxytropis gaspensis, Astragalus scrupulicola* (eastern ally of the Cordilleran *A. aboriginum*). Anse Pleureuse (Fig. 34) treasures *Gentiana propinqua* and *Oxytropis foliolosa*, both otherwise known only from Labrador and Hudson Bay; and *Draba nivalis* has been found near Ruisseau Sorel.

Scores of other allogenous elements make a precarious living all along this bleak rocky shore of northern Gaspé peninsula as far west as Le Bic. Le Bic is famous for its endemics and relics: *Arabis pendulocarpa, Nymphaea tetragona, Ranunculus lapponicus, Draba minganensis, Botrychium minganense, Woodsia oregana, Rosa Williamsii, Erigeron compositus* var. *mutifidus*, etc.

Now we cross the entire Gaspé peninsula to Percé, equally famous as a summer resort and as a geological riddle. There Percé Rock with its millions of Devonian fossils stands in the light, having for background, a few miles off-shore, the sheer red conglomerate cliffs of Bonaventure Island, teeming with bird-life.

Mt. Ste.-Anne at Percé harbors a very remarkable group of endemics and relics such as *Thelypteris Filix-mas, Draba pycnosperma, Erigeron compositus* var. *multifidus, Botrychium minganense, Saxifraga oppositifolia, Antennaria gaspensis, Oxytropis johannensis, Salix vestita, Amelanchier gaspensis, Arnica chionopappa*, and others.

We land on Bonaventure Island. A hanging rock about six feet square represents an important part of the entire kingdom of *Draba pycnosperma*, the rest of the known distribution being the near-by conglomerates on top of Mt. Ste.-Anne, one station at Tourelle, and one in northwestern Newfoundland.

If we travel now along Baie des Chaleurs, and botanize on the river gravels,

we find a complete mixture of the old allegedly interglacial elements and of the young aggressive Canadian flora.

The old elements are not all at high altitudes. In fact, most of them are exclusively at very low levels, sometimes near the sea, such as *Draba glabella* var. *megasperma, Dryas Drummondii, Astragalus gaspensis, Astragalus eucosmus, Lathyrus nevadensis* (Fig. 35) and *Listera borealis*. In the hypothesis of a mountain or nunatak origin, all these would have to be considered as having abandoned their former homes and migrated to the river gravels under the pressure of the sturdy denizens of the Canadian Spruce forest. This is a good sample of that anthropomorphic ecology that has crept surreptitiously in our minds, and is acceptable only on the ground that all living beings have much in common. Here is evidently a weak point in the theory as will be seen further on.

The marshes at the mouth of the Bonaventure River are apparently a commonplace habitat but, however, they treasure most interesting relics (Fig. 36). For instance we have here one of the few stations in continental Quebec for the coastal plain Rose *(Rosa virginiana)*.

Fig. 36. Estuary of the Bonaventure River, Baie des Chaleurs, Que., to this day the only known locality for the endemic *Gentiana gaspensis*. (Photo Marie-Victorin).

But far more interesting is *Gentiana gaspensis*, a frail monocarpic plant, and a relative of the well-known Fringed Gentian, growing among commonplace grasses and sedges. It has not been found outside of this particular marsh where it can be reached easily from the highway, an unfortunate possibility that may eventually lead to its complete extinction.

The organography of *Gentiana gaspensis* is quite typical of the whole crossopetalous group of Gentians, so well defined by their tetramerous corolla (Fig. 37).

We have here a fascinating group of plants, interesting in itself, and particularly so, as we have seen above, in its relations with the phytogeographical problems of eastern Canada. Here they are simultaneously endemics and relics, their Cordilleran affinity being evident in all cases. *Gentiana nesophila*

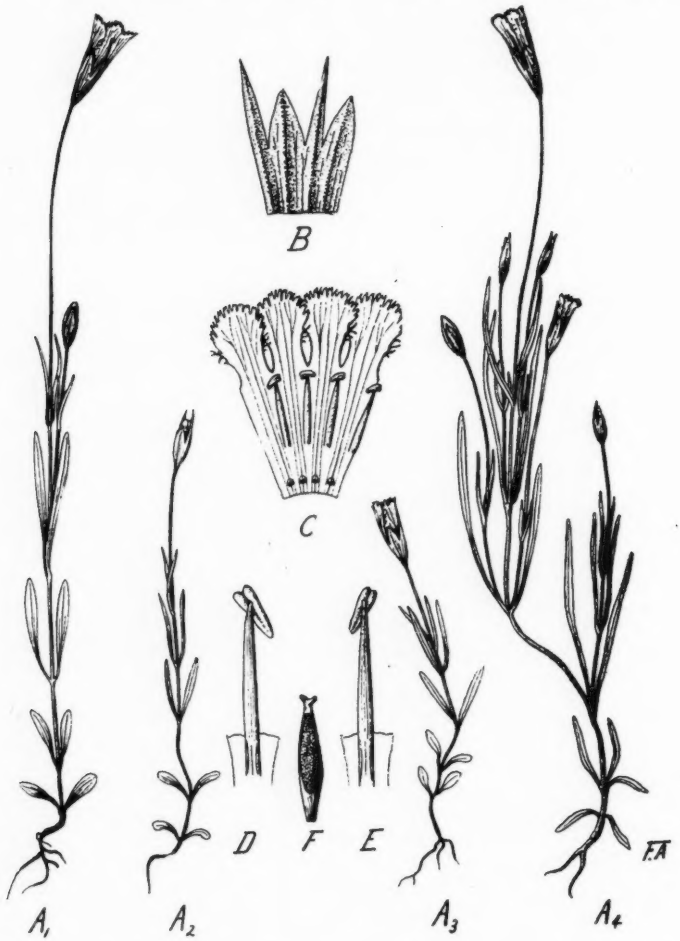

Fig. 37. *Gentiana gaspensis* Vict.—A1, A2, A3, A4) entire plants; B) calyx spread open; C) corolla spread open to show the stamens; D, E) stamens; F) pistil. (F. Alexandre, del.)

is a very local and boreal species found on barren gravelly soil by the sea-shore of James Bay, Newfoundland, Mingania, one spot on the north shore of the Gulf and Anticosti island. *Gentiana Victorinii*, whose entire distribution lies unquestionably within the limits of glaciated territory, — a condition which is difficult to reconcile with the nunatak theory, — must be charged with having migrated from an unknown Pleistocene or pre-Pleistocene center, and having developed peculiar adaptations since the Ice Age. It lives within the intercotidal zone of the fresh-water tidal shores of the St. Lawrence, and withstands daily

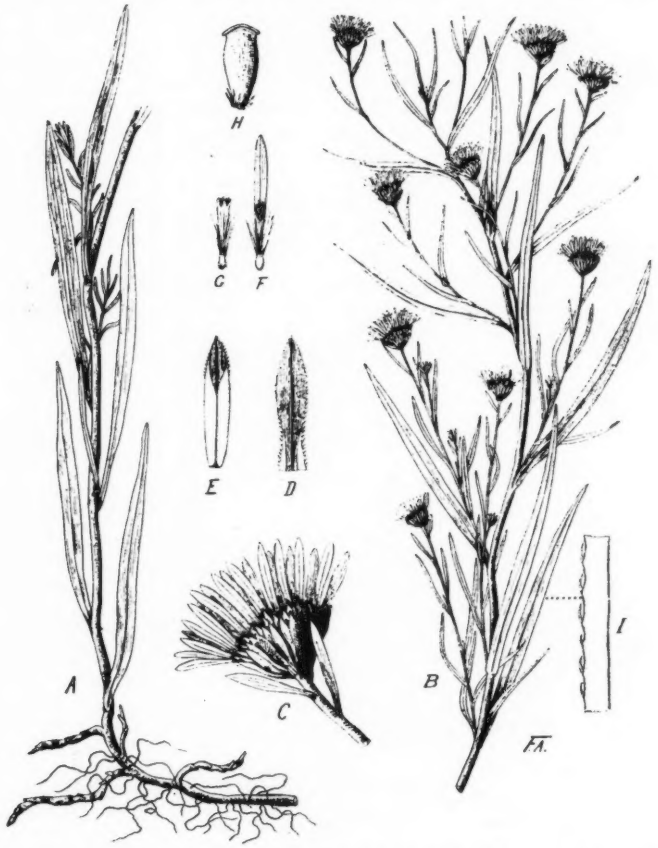

Fig. 38. *Aster gaspensis* Vict.—A, B) entire plant; C) head showing involucre; D) outer bract; E) inner bract; F) ray-flower; G) disk-flower; H) akene; I) ciliation of leaf (microscopic). (F. Alexandre, del.)

submersion at high tide, a unique feature amongst Gentians. *Gentiana Victorinii* is locally abundant, and in no danger of extinction, as can be seen on the tidal flats at Cap-Rouge, near the Quebec Bridge, where the plant blooms plentifully by the middle of August.

Perhaps an abridged sequence of the several stages involved in the professional search for relic species will be of interest here. I will illustrate this process by the narrative of the discovery and study of a new *Aster* of the Gaspé region: *Aster gaspensis* (Fig. 38).

There we are, on the swift Bonaventure River, poling our Gaspé boat, a craft built specially for these shallow and rapid salmon rivers. Setting foot on a gravel flat, roughly twelve miles from the sea, our attention is drawn to a clump of a beautiful sky-blue Aster. To an eye armed with a lens and trained in the complexities and endless variations of Asters, this clump presents nevertheless an unusual feature. The distinctive shape of the bracts under the heads, makes it sure that nothing of the kind has been seen as yet by human eye in eastern America. We are again confronted with an undescribed plant of Cordilleran affinity isolated in the east, and we proceed to the preparation of specimens in the old usual way, which has been so little improved since the days of Tournefort and Linnaeus.

Then we inquire about its local distribution, and we gather the unexpected fact that it is spread out only on a stretch of about three miles of gravel: from the twelfth to the fifteenth mile.

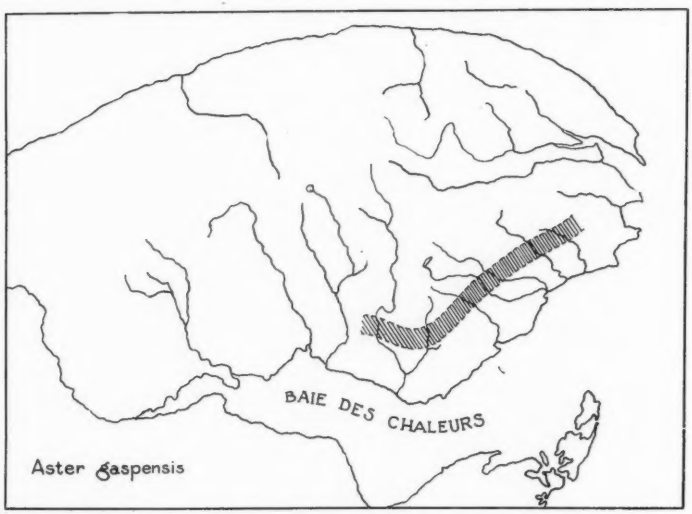

Fig. 39. Range of the endemic *Aster gaspensis*, suggesting the possibility of a migration along an old shore-line.

Later explorations have shown that the same situation obtains in the bed of other rivers draining the same basin: Grande Rivière, Petit-Pabos, Grand-Pabos, etc., so that an interrupted zone of this allogenous Aster seems to run parallel to the sea-shore at a distance of several miles (Fig. 39). With numerous collections now at hand, our concept of *Aster gaspensis* has somewhat evolved. Although remaining distinct from the *Aster longifolius* and the *Aster foliaceus* alliances, *Aster gaspensis*, as described, happens to be also, at the present time, a dynamic center of variation. These three species seem on the upgrade, while so many other relics behave as though they were sliding into extinction.

During the winter months, time will be given to the detailed study of the plant, to careful drawing and listing of characters, and to a discussion of its identity. The search for identity will be made by borrowing from the large herbaria of America their collections of Cordilleran Asters. From comparative study it will then become evident that the Gaspé plant belongs to a section of the genus characterized by the wide subequal bracts of the head, a section hitherto unknown in eastern America.

The Cordilleran affinity of the Aster under study invites to map the distribution of the section *Fulcrati* of the genus, thus showing beautifully one of those neat cases of geographical isolation that have led, for good or otherwise, to the proposal of the nunatak theory (Fig. 40).

I have as yet avoided the most difficult part of the problem. I refer to the endemics and relics of the Mingania-Anticosti district.

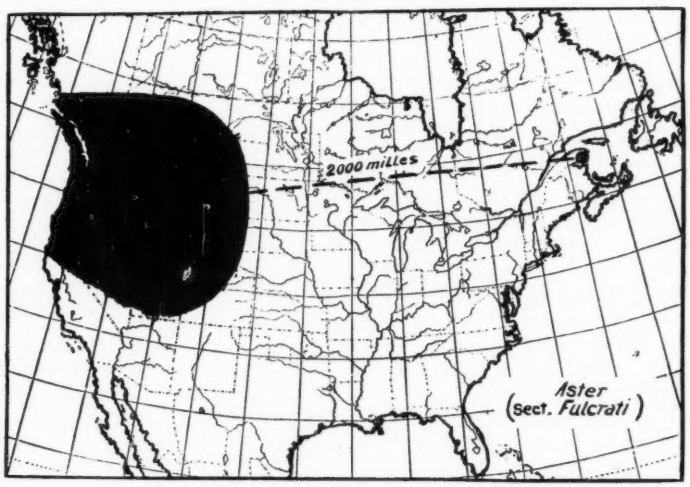

Fig. 40. *Aster* (Sect. *Fulcrati*). General western range of the group, and station of its unique eastern relic representative, *A. gaspensis*.

Fig. 41. Erosion witnesses (flower-pots) on Niapisca Island (Mingania). Tree vegetation made up mainly of *Picea glauca*. (Photo Marie-Victorin).

Mingania and Anticosti are closely connected geographically, geologically and biologically. They were a part of a shelf running along the north shore of the Gulf to Blanc-Sablon and Newfoundland. At a later stage the two lands were forming a peninsula protruding into the Gulf. Ultimately the isthmus crumbled and disappeared, leaving in its place the shallow Mingan Channel.

Physiographically, according to Twenhofel, the Mingania-Anticosti province is made up of the unsubmerged summits of three cuestas, of which two form Mingania and the third Anticosti. The channel between Mingania and Anticosti is due to the erosion accomplished by two "fossil" streams whose divide extended from North Point, on Anticosti, to Perroquet Island. The larger of the islands of Mingania are beautifully terraced, but it is not known when the major outlines of the terraces were formed. As regards glaciation, quoting Twenhofel's words, "the ice-sheet seems to have covered every one of the islands as shown by grooves, striae, and erratics."

Mingania includes twenty-two islands, large or small, all of them consisting entirely of undisturbed limestones gently inclined southward. The islands fringe the north shore of the Gulf for about 75 miles. The contrast with the nearby Precambrian mainland is very sharp, both in lithological and biological elements, except for some points of the mainland where Mingania strata are exposed.

The scenery in Mingania is very impressive. Erosion has carved the rocks into fantastic shapes. The so-called "flower-pots" of Niapisca, Grande Ile, Ile à la Proie, Ile Nue are sights not easily forgotten.

On Niapisca, for instance, can be seen one of the strangest objects left in

this land by the chisel of Time: in a lonely inlet, three grim stately towers crowned with northern flowers (Fig. 41). Nearby, Ile à la Proie has a rock table submerged at high tide, with a row of giant urns, rusty pilasters, and stelas. On Grande Ile, another weird display of fantastic gargoyles, rock caprices, and totem-like pillars. This topography has sometimes been interpreted as an indication of a nunatak area. That is probably going too far.

According to Twenhofel the "flower-pots" must be attributed to wave action. Wind action of course produces similar forms, but here the flower-pots are often in timber, and all are associated with seemingly post-glacial terraces.

Compared with Mingania, Anticosti is much more extensive, but much less picturesque. The north side is a series of moderately high cliffs (Fig. 42), whereas the limestones slope gently on the south side, often supporting extensive bogs. Shallow rivers flow on a coarse marble pavement, or bore their way through heavy gravels, sometimes widening into estuaries.

But however different physically, Mingania and Anticosti form but one biological province, very different from the mountainous Gaspé Peninsula barely fifty miles to the south, as well as from the nearby North Shore. The fundamental flora is made up of the subarctic Spruce forest, broken on Anticosti by peat-bogs and numerous shallow lakes. The Spruce is rather small, and the White Spruce of Anticosti is quite peculiar, sometimes assuming at a distance a Hemlock-like habit (Fig. 43).

An airplane view over northeastern Anticosti (Fig. 44) conveys an idea of the structure of this fundamental subarctic forest which is such as could be

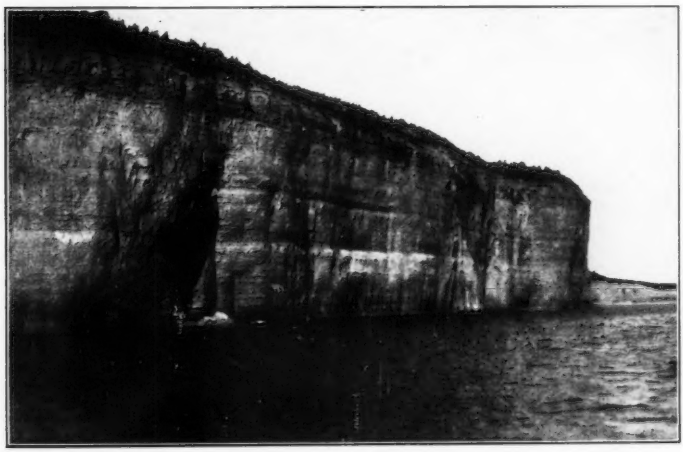

Fig. 42. Cap Henri, a fairly representative section of the north shore of Anticosti Island. (Photo Marie-Victorin).

Fig. 43. Typical Anticosti Coniferous forest, characterized by the small diameter of the old individuals of the dominant *Picea glauca*. (Photo Marie-Victorin).

Fig. 44. Airplane view over northeastern Anticosti, showing the falls and the canyon of the Vauréal river, the Spruce forest, and the numerous bogs and lakes. (Photo Fairchild Aviation Ltd.).

expected considering the climate, the high latitude and the limestone rock-floor everywhere present. But mixed with the fundamental flora of Mingania-Anticosti are a number of unexpected allogenous elements of different taxonomic affinity, and presumably of different origin, which we cannot but consider as relics of the past, and which constitute a seemingly senescent flora. A complete recital of this allogenous flora would here be impossible, but the more characteristic elements can be cited: *Draba glabella* var. *megasperma* (Mingania-Anticosti), *Draba laurentiana* (Mingania), *Botrychium minganense* (Mingania-Anticosti), *Scirpus pumilus* (Mingania-Anticosti), *Hieracium groenlandicum* (Anticosti), *Erigeron lonchophyllus* var. *laurentianus* (Mingania-Anticosti), *Gentiana nesophila* (Mingania-Anticosti), *Habenaria unalaschensis* (Anticosti), *Cirsium minganense* (Mingania), *Salix brachycarpa* (Anticosti), *Salix Bebbiana* var. *perrostrata* (Mingania-Anticosti), *Salix arctophila* (Anticosti), *Salix vestita* (Mingania-Anticosti), *Salix cordifolia* (Mingania-Anticosti), *Dryas Drummondii* (Mingania), *Erysimum coarctatum* (Mingania), *Draba minganensis* (Mingania), *Hedysarum Mackenzii* (Anticosti), *Salix arctophila* (Anticosti), *Carex microglochin* (Mingania-Anticosti), *Solidago Victorinii* and *Solidago anticostensis* (Anticosti), *Arctostaphylos rubra* (Mingania), *Senecio plattensis* (Anticosti), *Taraxacum laurentianum* (Mingania-Anticosti), *Rumex fenestratus* var. *labradoricus* (Anticosti), *Lesquerella Purshii* (Anticosti), *Antennaria pulcherrima* (Anticosti), *Braya humilis* (Anticosti), etc.

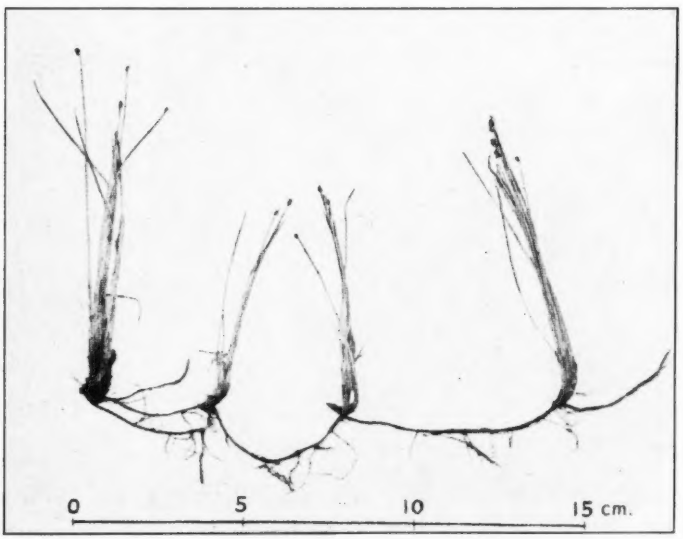

Fig. 45. *Scirpus pumilus*, an alpine but not arctic relic of the calcareous gravels of Mingania and Anticosti.

Scirpus pumilus (Fig. 45) is a true alpine plant which, at the time of its discovery in Mingania, was known in America only from one distrusted collection made in Denver, Colorado, more than half a century ago. The local distribution as now known includes the Mingania tundras and the river gravels of Anticosti. The general distribution shows that it is essentially an alpine plant, but not really arctic or subarctic. It also shows extreme discontinuity. Its presence at sea-level, in eastern Quebec, is a far-reaching fact, and linked with numerous other instances, calls for a more or less important amendment to the nunatak theory (Fig. 46).

No one would imagine that a bleak, barren Mingania sea-cliff could be the last refuge of *Cypripedium passerinum*, a familiar Orchid of the Pine woods

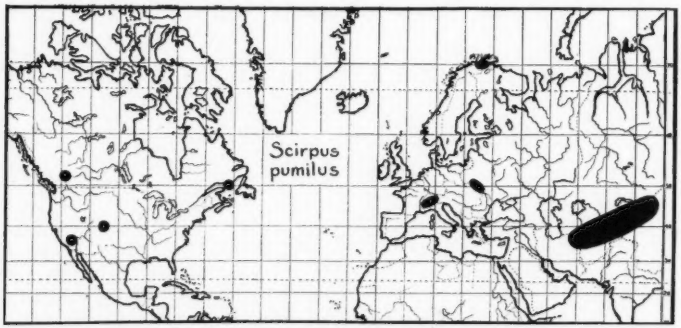

Fig. 46. General distribution of *Scirpus pumilus*.

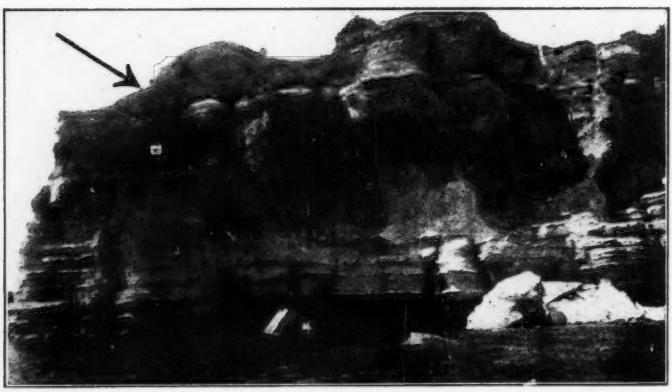

Fig. 47. Cliff of Ile à la Vache marine (Mingania). The arrow indicates the tundra pocket where *Cypripedium passerinum* var. *minganense* was first found. (Photo Marie-Victorin).

of the Rockies, so beautiful with its purple-spotted lip, just like a bird's egg (Fig. 47). In Mingania the plant grows among the Sphagnum and rank Sedges, in rock crevices exposed to the fury of the gales, or even on the gravel-spit by the seashore, within reach of the tide.

A study of its distribution indicates that *Cypripedium passerinum* is a wide-ranging endemic Canadian species, but not really arctic. The extension of this Orchid to the Gulf of St. Lawrence might be, in the nunatak hypothesis, a good illustration of the universality during the last interglacial period of the present allogenous flora. But as in many other instances this distribution can be explained otherwise.

Of course the discovery of a new eastern Lady's Slipper is something eventful enough in a field botanists's experience. But perhaps, the greatest thrill I ever experienced in the field was the discovery of the Mingania Thistle.

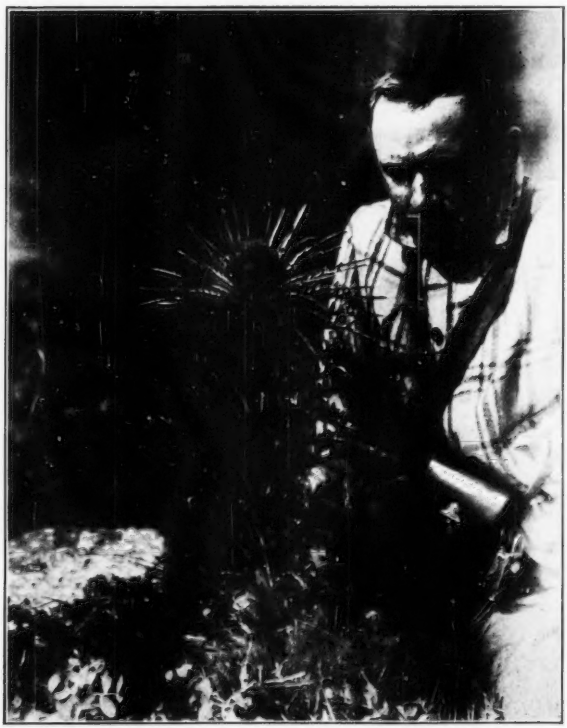

Fig. 48. *Cirsium minganense*, an exclusive Minganian endemic, allied to a group (sect. *Foliosae)* of Cordilleran Thistles. Author standing by. (Photo Marie-Victorin).

On a delightful evening of July 1924, my fishing boat, the "Virginia," thirty feet from bow to stern, had just reached for the night a secluded cove on Ile Quin, in Mingania. I went ashore to get a glimpse of the flora and to see what novelties could be had there. The tide was low, and I had to wade for some time amongst Laminarias before I could reach the limestone shingle and gravel, where, as a rule in this northern country, *Elymus arenarius* var. *villosus, Senecio pseudo-Arnica* and *Lathyrus japonicus* reign supreme.

But there a great surprise was in store for me. Over these ubiquists of the seashore towered a plant no eastern botanist ever dreamed of. A dozen tall pale-green Thistles, ghostly and unreal, with pinkish heads clustered into a compact terminal mass surrounded and subtended by an elegant pseudo-verticil of long leafy bracts. This plant, evidently an undescribed species, I published later as *Cirsium minganense* (Fig. 48).

In years of subsequent exploration it has been found that the Mingania Thistle does not exist in Gaspé, nor in Anticosti, nor in Newfoundland, but seems to be restricted to half a dozen definite seashore spots in the archipelago. My estimate is that actually there are not much more than a few hundred plants in existence.

Now, if we examine the taxonomic characters of the Mingania Thistle,

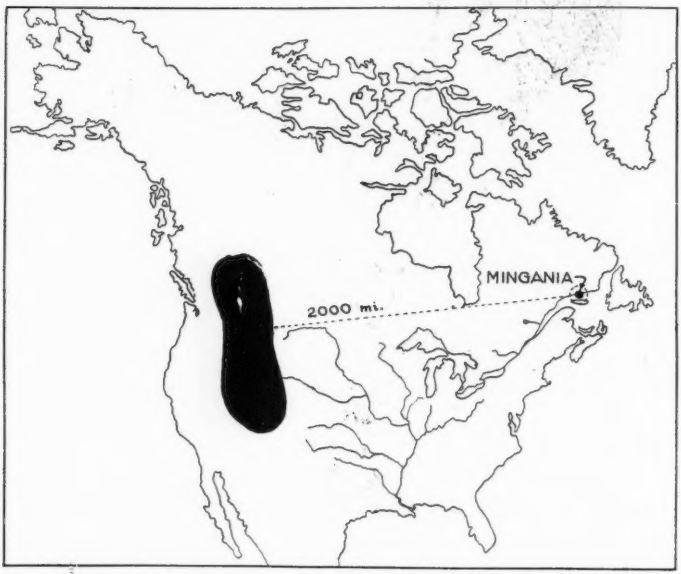

Fig. 49. Distribution of *Cirsium* (sect. *Foliosae*) showing the extreme isolation of the Minganian stations.

we find that it belongs to a group of Rocky Mountain Thistles, the section *Foliosae*, inhabiting alpine meadows.

Cirsium minganense is not identical with any member of the *Foliosae*, as can be seen by comparison of the leaf and bract with its nearest relative

Fig. 50. Habitat of *Cirsium minganense*, by the seashore of Mingania. The plants grow at the top of the zone of *Lathyrus japonicus*. In the background a thicket of Alder *(Alnus mollis)* and subarctic Willows *(Salix vestita, S. glaucophylloides, S. discolor* var. *Overi, S. cordifolia*, etc.). (Photo Marie-Victorin).

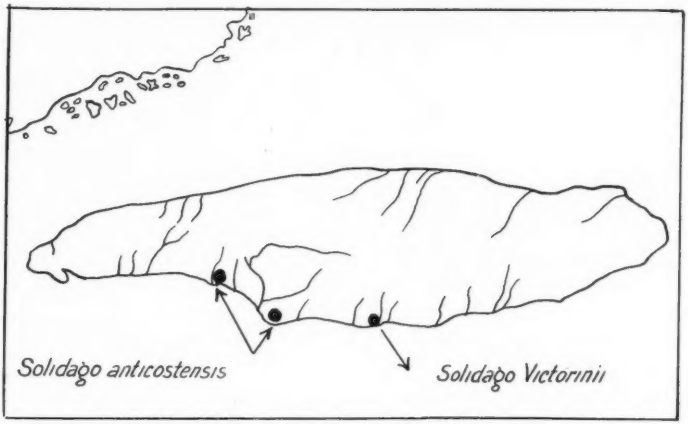

Fig. 51. Extreme endemism in Anticosti plants as exemplified by the distribution of *Solidago anticostensis* and *Solidago Victorinii*.

Cirsium Drummondii, and I feel secure in considering it as a new species, a true Minganian endemic, differentiated by isolation during or after the Pleistocene.

Figure 49 shows the general distribution of the group in western America, and the extraordinary geographical discontinuity of the relic eastern representative.

Once more we note that around the Gulf of St. Lawrence, seemingly a majority of the relics congregate on the seashore, although the habitats of the identical or the nearly related plants of the Rockies are sometimes very different. Does the struggle for life ineluctably drive them here on the seashore where the ecological pressure of other species is lighter? Or else was the gravelly and fully-lighted seashore just a convenient pathway for their post-Pleistocene migrations in a thickly-forested country? Or are we dealing with an obscure equivalence of habitat?

One must not overlook the fact that the Mingania Thistle, like all Thistles,

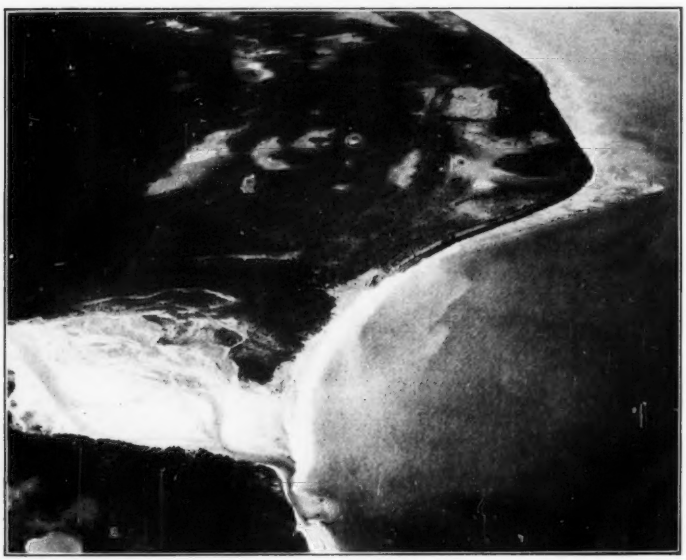

Fig. 52. Airplane view of a portion of south central Anticosti Island, showing (left) the estuary of the Jupiter River and (right) South-West Point, localities famed for their allogenous elements. On the limestone gravels of the wide estuary can be found *Antennaria pulcherrima, Tanacetum huronense* var. *bifarium, Braya humilis, Lesquerella Purshii, Orobanche terrae-novae, Arctostaphylos rubra, Salix brachycarpa,* etc. The edge of the gravelly low plateau of South-West Point is occupied by *Erigeron lonchophyllus* var. *laurentianus, Drosera linearis, Gentiana nesophila, Solidago anticostensis, Salix arctophila, S. vestita, S. brachycarpa, S. cordifolia, S. brachycarpa* x *S. cordifolia,* etc. (Photo Fairchild Aviation Ltd.)

Fig. 53. *Dryas Drummondii*, a Cordilleran relic, with *Populus tacamahacca*, both pioneering on the calcareous gravels of Petite-Cascapedia River, Gaspé Peninsula. (Photo Marie-Victorin).

produces every year thousands of plumed seeds, scattered landward by the strong breezes of the Gulf (Fig. 50). Why then is the plant so restricted in its distribution? Why is it apparently dying away? And this is indeed no exceptional case. In the district under consideration, most very local species belong to families the seeds of which are provided with unusually effective means of dispersal.

For instance the endemic Goldenrods of Anticosti, *Solidago anticostensis* and *Solidago Victorinii*, are recorded only from one or two stations (Fig. 51). Yet everybody knows how aggressive most Goldenrods are.

Salix brachycarpa, so abundant in western America, is a relic in the East. Like all Willows, its seeds are produced abundantly and equipped with the regular tuft of cotton. Nevertheless this species is confined to the top of Mt. Albert in Gaspé, and to the gravels of Jupiter River and the neighboring low plateau on Anticosti. Such is the case for many other depressed species of willows (Fig. 52).

Another case is *Dryas Drummondii*, also a relic species of eastern Canada. The light and mobile plumed fruits do not seem to be instrumental in extending its distribution west of Mingania, Cap des Rosiers and the Little Cascapedia River. The latter locality, from some obscure cause that may be linked with glaciation, acts as a western limit for quite a number of the Gulf of St. Lawrence endemics (Fig. 53).

I could multiply the instances, and show that the sea-level relic flora of Anticosti and Mingania is fully as rich as that of the highlands of Gaspé and other reckoned unglaciated districts. But geologists seem to agree that the districts under consideration have been heavily laden with Wisconsin ice, and, moreover, have afterwards been submerged in Champlain times.

These facts seem, on first examination, to oppose rather bluntly the

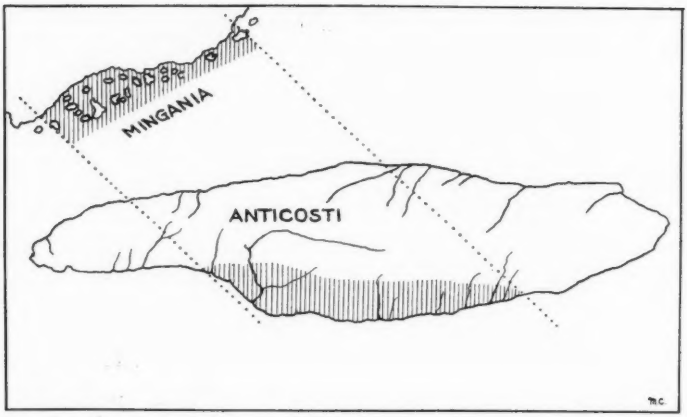

Fig. 54. Peculiar distribution (shaded areas) of the allogenous elements of the Mingania-Anticosti flora, suggesting a nunatak area between two tongues of ice, or partial submergence in Champlain times.

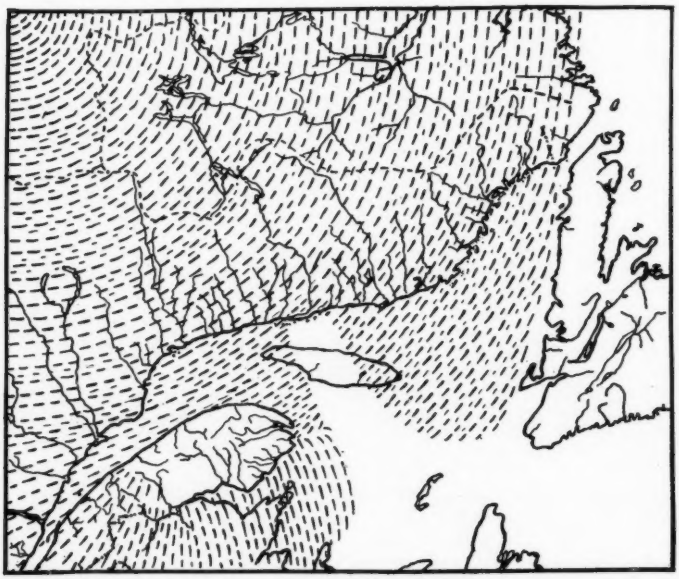

Fig. 55. Map showing a possible behavior of the Wisconsin ice, to explain the remarkable endemism of Gaspé, Newfoundland and Mingania-Anticosti floras.

nunatak explanation. How then can the peculiar flora of this district be accounted for?

Painstaking exploration has revealed the astonishing situation shown in Fig. 54. The endemics and relics are crowded in Mingania, and along a shore approximately the same length on southern Anticosti.

In the present state of science, and pending a more thorough geological and glaciological survey of the Mingania-Anticosti unit, I have suggested, on biological grounds only, the following hypothetical sequence.

During the Tertiary or the early Pleistocene, migrations to Anticosti and Mingania, from northern Europe and perhaps from the Rockies, progressed along the then continuous limestone shelf bordering the north shore of the Gulf. Some of the older elements were not destroyed by the late or Wisconsin glaciation because they were shielded in the angle between flowing tongues or masses of ice on either side of Anticosti (Fig. 55). The Champlain submergence was not as complete as has been thought and a relatively small number of the elements was not destroyed. The present distribution of Anticosti relics seems to point to a place of refuge somewhere on a then higher land near the head-waters of the Chicotte and Vauréal rivers. The conditions on the dwindled Anticosti of Champlain times were something like open meadows, or gravel barrens, such as prevail even today in some part of the island: Sand-top, etc. (Fig. 56). With the gradual emersion of the land after the Champlain period, the Canadian Spruce forest invaded the open meadows, and the plants now listed as relics, such as *Scirpus pumilus, Lesquerella Purshii, Braya humilis, Arctostaphylos rubra, Hedysarum Mackenzii,* and scores of others, unable to struggle with the sturdy Laurentian invaders, were gradually confined to the banks or gravels of the rivers, the only places where congenial or at least minimum conditions were left to most of them.

Fig. 56. Sand-Top, Anticosti Island, showing marine terraces. Tundra-like vegetation, slightly halophytic in character, with *Carex Lingbyi* and *Gentiana nesophila* as remarkable allogenous elements. (Photo Marie-Victorin).

Some mesophytic shade-loving species, however, mainly Orchids, such as *Habenaria unalascensis* and *Listera borealis* (Fig. 57) became embodied in the biocenosis of the coniferous forest. It now takes a trained eye to decipher through the meshes of the hypnaceous moss carpet of the Spruce forest the two phytogeographical stories silently told by the "lips" (the specific differences here largely lie in this part of the flower) of *Listera borealis*, the Old one, and *Listera cordata*, the Newcomer! When all is said, the present relic flora represents only a small portion of an interglacial flora, the screenings, one may say, that have withstood the vicissitudes of the post-Pleistocene (Fig. 58).

I have so far, for the sake of convenience, recounted the facts in connec-

Fig. 57. *Listera borealis*, a strictly sciophytic Cordilleran relic of Mingania-Anticosti and Gaspé, which, unlike most northeastern relics, has merged completely with the common denizens of the spruce forest: *Listera cordata, Clintonia borealis, Oxalis montana, Cornus canadensis*, etc.

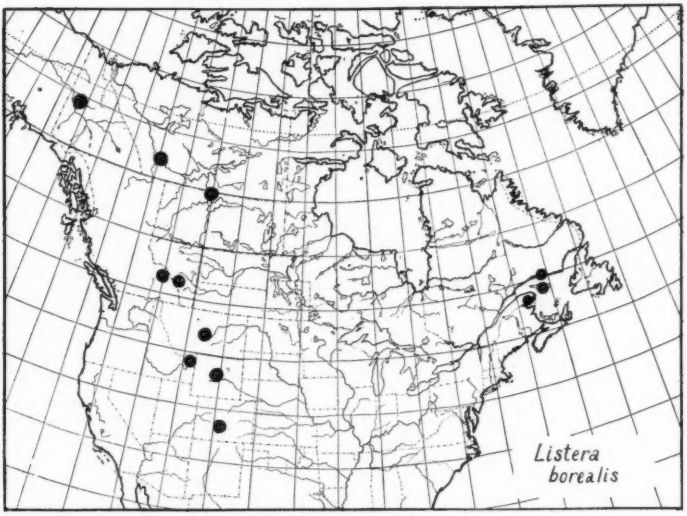

Fig. 58. Distribution of *Listera borealis*.

tion with the allogenous flora of eastern Canada, by linking the origin of relics and endemics with glacial and interglacial episodes and phenomena. As will have been noticed, exception has been taken freely at certain points along the way, and certain doubts formulated as to the general application of the nunatak explanation.

I might now declare more explicitly that after more than a quarter of a century of unusually good field work, of careful study of identities by able systematists, and of strenuous effort, — constantly defeated however by more and more analysis, — towards synthesis and integration, this whole chapter of plant geography should be rewritten.

Wynne-Edwards, in a recent paper, has attempted to do so. His main points, if I read him correctly, are that we should get back to Hooker's classical hypothesis, i.e.: "that the arctic-alpine flora of eastern North America has formed a single unit since pre-Wisconsin times; that in those times, it occupied suitable habitats in latitudes similar to, or higher than now; that with the advance of Wisconsin glaciation it was driven southwards and outwards; and finally that with the retreat of the ice a recolonization of the suitable habitats took place. The ecological differentiation associated with calcareous, magnesian, magnesian-calcareous and lime-soda soils . . . provides the key to the present disrupted ranges of these plants, without recourse to the question of survival in insulated unglaciated areas . . . Not all the soil-specialized species of the region have as yet had opportunity to reach all the suitable habitats, and some are found in this place, others in that place."

Every experienced field-botanist knows of course the more or less exacting soil preferences of certain plants, and will agree, partly at least, with the statement made almost a century ago by a geologist, Sir William Dawson: "For many of the plants of the Laurentide hills to extend themselves over the calcareous plains south of them, under any imaginable conditions of climate, is quite as far beyond the range of possibility as to extend across the wide ocean."

But one cannot without danger reverse the statement, nor can one use safely the chemical explanation of distribution, except as applied to very general situations. Without re-opening a discussion that was the great ecological theme in pre-Warming days, it seems certain that some plants may be chemically indifferent under certain conditions of latitude or climate, and calcicolous being given another set of conditions. For instance *Acer nigrum, Ulmus racemosa, Celtis occidentalis,* not distinctly calcicolous within their main areas, are almost exclusively so in southeastern Quebec where they reach their northern limit. And it so happens that many plants of rather indefinite preference can maintain themselves in the north only by creeping on the limestones of Mingania, Anticosti and similar regions. Nothing is more illuminating in this respect, than the observations made at the well-known British Experimental Station of Rothamsted in 1929. The winter had been very severe and late frosts greatly damaged the experimental plots. Some of the plots had received annually for a number of years a supply of lime, whereas the adjacent plots were used as controls. On the untreated controls grass was

Fig. 59. Rothamsted Experimental Station, England. Effect of severe winter of 1929 and of heavy late frosts on the experimental plots. Left: healthy plot which had been supplied with lime. Right: untreated control plot, where nearly all grass plants have been killed. (Photo Marie-Victorin).

entirely wiped out by killing frosts; the plots treated with lime suffered little or no damage (Fig. 59).

I have often thought that the xerothermic limestones of Mingania, Anticosti, etc., can explain some general features of the flora, but that they are of little use in the search of an adequate solution to the individual problems of the so-called relic species.

It will then be seen that we are here invited by Wynne-Edwards to come back to the simple faith we held forty years ago, prior to the period when the wealth of relic and endemic identities unearthed from year to year in Gaspé, Mingania-Anticosti, Newfoundland and other places, suggested a more complex history, and gave birth to the nunatak theory.

For lack of personal acquaintance with certain parts of the territory such as Newfoundland, and for some other reasons as well, I am not ready at the present moment to enroll in extreme faiths and to undertake to rewrite myself this important chapter of plant geography. For the time being, I only want to point out some of the difficulties of the nunatak theory, and on the

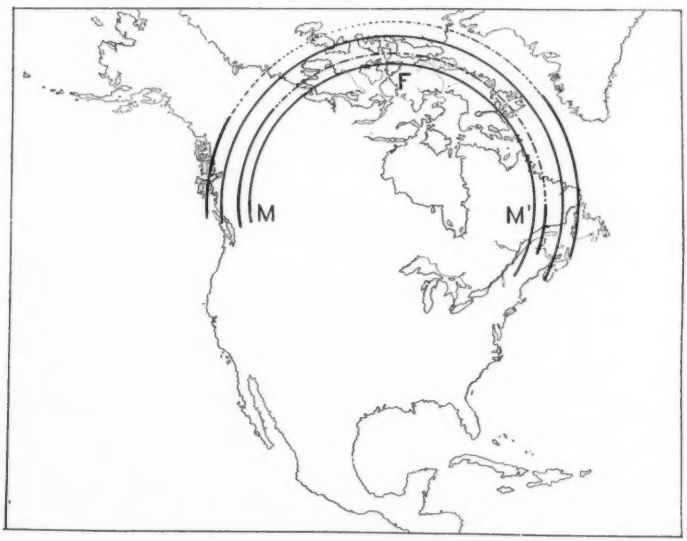

Fig. 60. The "rainbow" explanation of the occurrence of the so-called Cordilleran relics in northeastern America: both arctic and Cordilleran plants are arcto-Tertiary units that have migrated from their high arctic station (F) along the two main paths offered to them on either side of Hudson Bay. According to this view, the so-called Cordilleran plants would be just ancient arctic plants that have disappeared from the Arctic, and persisted at one or both ends (M and M') of their migrating trails. (Full lines indicate present essentially continuous distribution; dotted lines mark supposed local extinction and present discontinuity).

other hand to express the opinion that the return to Hooker's simpler explanation of the isolated floras does not seem to cover all the facts on record.

Perhaps, one of the weakest points of Fernald's nunatak hypothesis, at least in the early statements, is the sharp distinction stressed or maintained between truly arctic and Cordilleran plants, the latter in the sense of plants having migrated from the Cordillera eastward in preglacial or interglacial times. The abandonment of this distinction would perhaps clarify the situation and strengthen the case. May not all, or most, of the plants concerned, be considered as arcto-tertiary plants having migrated from their high northern station along the two main paths offered to them on either side of Hudson's Bay? May not most of the so-called Cordilleran plants be just arctic migrants that for some reason or other have become extinct in the Arctic and have persisted at one or both ends of their migrating trails? (Fig. 60).

This dynamic view of the situation, that could be labelled the "rainbow explanation," perhaps meets Wynne-Edward's statement (loc. cit. p. 10) which, however, refers only to the present static condition: "Some of these plants have wide limits of climatic tolerance, occurring through a wide latitudinal range, in which case their American distribution takes the form of an arch spanning the continent from the Cordillera to the St. Lawrence by way of the Arctic; while others are more narrowly confined, the hardiest occupying the crown of the arch and least hardy its two ends, whereby their ranges are disrupted into western and eastern centres."

This hypothesis, not more imaginative or hazardous than the others, would explain in a very simple way not a few puzzling distributional maps. It would also take care of a number of future discoveries. Is it not evident that distributional maps showing striking disjunction and isolation rest mainly on negative evidence? It is obviously dangerous to speculate too freely on the absence of certain species in territories which are notoriously botanically unexplored, such as the north shore of the Great Lakes, the Hudson Bay shores, the whole of northern Quebec and large sections of Gaspé and Newfoundland.

The large number of so-called Cordilleran relics, or of endemics of Cordilleran affinity, which are found to-day at sea-level, either in apparently unglaciated or obviously glaciated districts of the Gulf of St. Lawrence region, is another far-reaching fact that carries one away from the nunatak idea. Having chosen for my personal field-work Anticosti, Mingania, and the north shore of Baie des Chaleurs, I was no less successful in the search of allogenous elements, than the botanists of the same feather who concentrated on the highlands. There is no doubt for instance that the gravels of Little Cascapedia River, of Bonaventure River and other streams of the Baie des Chaleurs basin are richer in allogenous non-arctic elements (*Aster gaspensis, Gentiana gaspensis, Astragalus gaspensis, Astragalus eucosmus, Lathyrus nevadensis, Dryas Drummondii,* etc.) than the nearby Table-top Mountain.

In this connection, one must not only think about very localized relics, but also about a number of bicentric species, rather general or frequent on the lower St. Lawrence: *Zigadenus elegans, Juniperus horizontalis, Senecio pseudo-*

Arnica, Rumex persicarioides, Rumex pallidus, Poa eminens, Iris setosa var. *canadensis, Aster angustus,* etc. and whose Cordilleran or Asiatic affinity or identity must be accounted for.

With these well-established facts in mind, one cannot refrain from thinking that we have to consider not only sedentary relics that may not have migrated since scores of millenniums, but also a host of allogenous elements brought in as the result of migrations, presumably of several systems or waves of migration.

A look at the map (Fig. 61) showing the Champlain Sea at its highest extension in northern Quebec suggests the possibility of a post-Pleistocene migration from James Bay to the Gulf of St. Lawrence, along an almost continuous seashore through northern Quebec. A botanical exploration following this physiographic line would perhaps bring surprising results. But we already know, from the field work of Potter and others, a group of remarkable

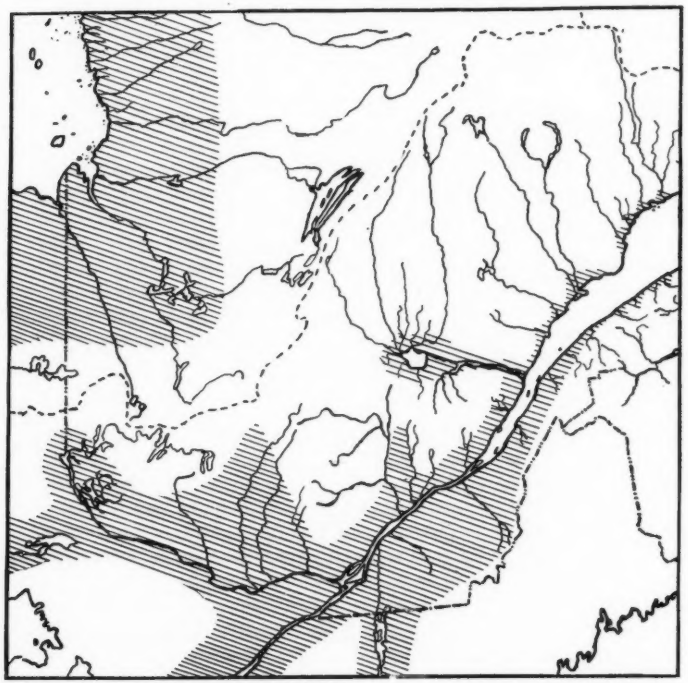

Fig. 61. Maximum marine invasion during the Champlain period, suggesting the possibility of a marine communication between the Champlain Sea and James Bay, and of plant migration along a continuous seashore. (After Potter).

EXPLORATION BOTANIQUE DU QUÉBEC
PLANTES DE L'ILE D'ANTICOSTI
No 25.583
10 août 1926
Antennaria pulcherrima (Hook.) Greene
RIVIERE JUPITER sur les plattères de l'embouchure.-Très abondant.

Fig. 62. *Antennaria pulcherrima*, a Cordilleran relic of the Anticosti rivers and Hudson Bay.

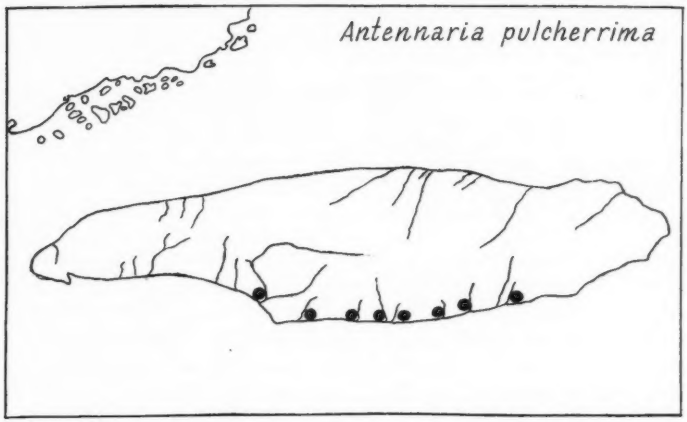

Fig. 63. Local distribution on Anticosti Island of *Antennaria pulcherrima*. Several other relic species (*Lesquerella Purshii, Braya humilis*, etc.) have almost exactly the same local distribution.

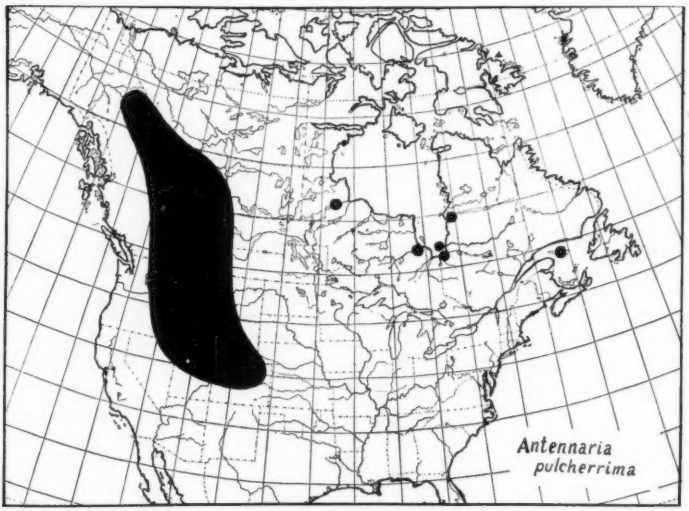

Fig. 64. General distribution of *Antennaria pulcherrima* with its outliers on Hudson Bay and Anticosti.

seashore relics featuring this bicentric distribution (James Bay — Gulf of St. Lawrence), with no recorded intermediate stations in or around the Ungava peninsula.

The marine and estuarine elements of this bicentric group include: *Bidens hyperborea, Carex norvegica, Juncus Gerardi, Poa eminens, Glaux maritima* and others. But this biological relation between the two territories is even more strikingly exemplified by very local terrestrial plants such as the showy *Antennaria pulcherrima* (James Bay and Anticosti), *Cypripedium passerinum* (James Bay and Mingania), both of them also denizens of the Rockies; *Draba minganensis* (James Bay, Mingania and Le Bic), an ally of *Draba luteola* of the Rockies; *Gentiana nesophila* (James Bay, North Shore of the Gulf of St. Lawrence, Anticosti, Western Newfoundland). (Figs. 62, 63 and 64).

The distribution of *Gentiana nesophila,* and indeed that of the whole group of crossopetalous Gentians in the east, is more suggestive of complex phytogeographical events, than of a simple story of glacial isolation, or of the movements of a solid floristic unit held together since pre-glacial times. On the other hand, such extremely local low-level or seashore relics as *Cirsium minganense, Cypripedium passerinum* var. *minganense, Erigeron lonchophyllus* var. *laurentianus, Scirpus pumilis, Gentiana gaspensis,* although undoubtedly related to, or identical with, so-called Cordilleran species, do not fit in very well with the nunatak explanation, and call for some amendment or some other hypothesis.

Does not for instance the peculiar distribution of *Aster gaspensis,* found on several successive Baie des Chaleurs rivers, between the twelfth and fifteenth mile from the seashore, suggest a migration along an old Champlain sea beach, rather than a local nunatak origin? (Fig. 39).

A last word on a point that might have been raised at the very outset of this study. Is the conception of a senescent preglacial or interglacial flora, vanishing gradually from northeastern America, defensible on biological grounds? Are there really such things as senescent species, and senescent floras in the present world?

I have often caught smiles on the lips of my biological auditors, when indulging in such anthropomorphic utterances. But I do not think we can escape a more or less guarded admission of this kind, if we look at the facts without bias. The past history of the plant world has much in store about dead species and dead floras. Without searching out of Gaspé, the famous Devonian formations of Escuminac, on Baie des Chaleurs, show a world of extinct fishes buried with a world of extinct Pteridophytes and Seed-ferns, whilst the solid rocks of Cross-Point conceal the unsolved mystery of *Prototaxites (=Nematophycus).* Although we have no means to know how death came to the Pteridosperms, to the Psilophytales, to the giant Lycopods, and to so many strong vegetable types, we can imagine that they did not disappear suddenly, and that at a certain period, notwithstanding their apparent fitness with the environment, they were slowly dying away.

The trained field botanist, working in the cliffs of the Gulf of St. Law-

rence, has somewhat the sensation of witnessing that very process of regression and elimination which the world has seen so often. He cannot but notice that many of the extremely local relics, confined to one island cove, to a solitary sea-cliff, to one mountain crag, belong to groups extremely well outfitted to spread far and wide, mostly Salicaceae and Compositae.

The Mingan Thistle *(Cirsium minganense)*, in spite of its large size, and of its thousands of plumed seeds, is so well protected by its confinement into a few small coves of Mingania, that it had escaped attention until 1924.

Dryas Drummondii of the Gaspé gravels, stops short westward, at the Little Cascapedia river. The endemic *Taraxacum laurentianum*, a sturdy dandelion of the gravel-bars of Mingania, Anticosti, and western Newfoundland, sends out its seeds in the same fashion as the ubiquitous plant we all know, but the endemic plant has nevertheless a very restricted distribution.

Such extremely local plants as *Cirsium minganense* certainly seem to be doomed. If we could prove with reasonable certainty that these forms are disappearing because they are "old" to the point that some essential mechanism has ceased to be functional, we could open a new chapter of auto-ecology, and grasp at least one of the negative aspects of evolution.

But we are now in possession of a first series of experimental data in connection with the "health" of the allogenous units of eastern North America. A certain number of the rarest relics and endemics have been grown for the last two years in the Montreal Botanical Garden. Quite unexpectedly they are very successful. *Aster gaspensis* spreads rapidly through its underground system. *Erigeron compositus* is self-sown and tends to become weedy on the artificial limestone gravel beds. *Cirsium minganense* has germinated and enjoys the Montreal climate. *Arnica chionopappa* is overgrown and produces tremendously numerous and vigorous rosettes. *Solidago multiradiata*, which in my personal experience at Cap Gaspé, had not spread outside its narrow cornice for the last fifteen years, here behaves as aggressively as any other Goldenrod. *Antennaria gaspensis* and *Antennaria rupicola* override their assigned places and flow on all sides in dense mats.

What of it? Since there does not seem to be anything fundamentally senescent or lethal in the plants themselves, we are naturally led to concede the senescent condition to the allogenous flora as a whole, to consider the relics as being crowded out by a notable change in the environment, climatic or otherwise, bringing about a strong pressure from the more commonplace elements of the tundra and Spruce forest complexes. The other alternative, namely that the allogenous elements are not relics but new-comers, arctic plants, a rear-guard coming back again from the south on the heels of the vanished Wisconsin glacier, leaves without explanation scores of individual cases such as that of the strictly endemic *Gentiana gaspensis, Aster gaspensis, Cirsium minganense.*

To sum up, the situation seems much too complex for one good simple, schematic and dogmatic explanation. There is evidently a general truth in Hooker's hypothesis of a back and forth "mouvement d'ensemble" of the

whole flora of eastern Canada during and after Pleistocene times. There is also much in favor of the nunatak theory, which may be necessary or helpful to explain a number of cases. How else can the presence of *Agoseris gaspensis* on Table-top Mountain, of *Salix brachycarpa* and *Polystichum mohrioides* on Mt. Albert be explained, notwithstanding the magnesian preference of the latter species?

But we cannot round out all the facts without admitting more or less intricate and massive Pleistocene or post-Pleistocene migrations. Picturing the dry unforested belt that must have existed along a receding ice-front, as a kind of side-walk extending from the Rockies to the Gulf of St. Lawrence, undoubtedly helps to understand the presence of a good number of sea-level and highly isolated plants, of evident Cordilleran affinity. I see no other way, for instance, to justify the present exclusive home of *Cirsium minganense*.

Such is the kind of questions certain brand of botanists whose laboratory is no smaller than the biosphere, worry about. Wise or unwise, they are concerned with the life of species, and the life of the floras which they consider as real units, as real collective individuals that are born, live a while and inevitably die.

Although this pruning of the Tree of Life outlined above goes on recklessly in Time and Space, one should not understand that the Tree itself is gradually losing its vitality. The world has outlived the era of Gymnosperms, and *Homo sapiens* is adapted to an Angiosperm environment. We do not know what will come next, but reasoning by analogy, we can think that something better, or different, of which we have no premonition, is slowly evolving, unnoticed, amongst the multitude of Angiosperm devices. But apart from this phylogenetic advance where the factor Time is supreme, there is a very evident advance in Space going on even within the narrow limits of History.

While in a given corner of the Earth, species may become extinct and associations be wiped out, other species may gain strong foothold on new territory. Confining ourselves to the portion of the biosphere we have been considering so far, eastern Canada, we find that, through the agency of man, many Old World plants have found a way to our shores, and in certain cases, have transformed entirely the outlook and ecology of our landscapes.

What would be our Spring without the glory of Dandelions *(Taraxacum officinale)*, and our summers without the Daisies *(Chrysanthemum Leucanthemum)*, the Vetches *(Vicia Cracca)*, the Mustards *(Brassica spp.)* and other Mediterranean immigrants that have made good here, sometimes against our wishes. How the Old World *Plantago major* walked on the heels of white man in America and disputed the ground to the almost identical native plant; how *Artemisia vulgaris*, brought in the St. Lawrence valley by our great-grandmothers as an emmenagogue, became an almost natural member of our flora; how *Galinsoga ciliata*, a New World tropical immigrant, became our most typical city weed? All these stories of plant introductions are interesting, sometimes fascinating and amazing.

Long ago, the Purple Loosetrife, *Lythrum Salicaria,* on its way to girdle the globe, alighted on our fresh-water shores and spread over the shoals and alluvial flats of the St. Lawrence River an immense and almost continuous purple mantle (Fig. 65). But *Lythrum Salicaria* belongs to a very definite ecological type. It is not an aquatic, nor a semi-aquatic, but it finds a congenial habitat on low grounds that are submerged in spring-time, but dry up during the summer. This ecological preference left room for a semi-aquatic

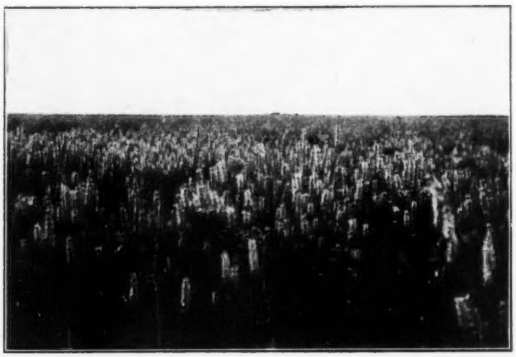

Fig. 65. Over the shoals and alluvial flats of Lake St. Peter, on the St. Lawrence River, *Lythrum Salicaria* spreads an almost continuous purple mantle. (Photo Marie-Victorin).

Fig. 66. A pure stand of *Butomus umbellatus* on the shoals of the St. Lawrence River near Montreal. Semi-aquatic condition. (Photo Marie-Victorin).

that could thrive equally well, at least vegetatively, in deep or shallow water, as well as on seasonally emerged shores.

Of such semi-aquatics there are several in the indigenous riparian flora of the St. Lawrence River. But they are kept within definite limits by a long-established adjustment, and by the never-failing balance of parasites. Then appeared, nobody knows how, a short time before 1900 probably, a hardy and beautiful Alismaceous plant, *Butomus umbellatus,* the Old World Flowering Rush. Spreading very rapidly by means of its seeds, rootstocks and bulblets,

Fig. 67. Emersed shoals at Boucherville, on the St. Lawrence River near Montreal, showing an almost pure population of *Butomus umbellatus,* a European Alismaceous plant recently naturalized in America. Terrestrial condition. (Photo Marie-Victorin).

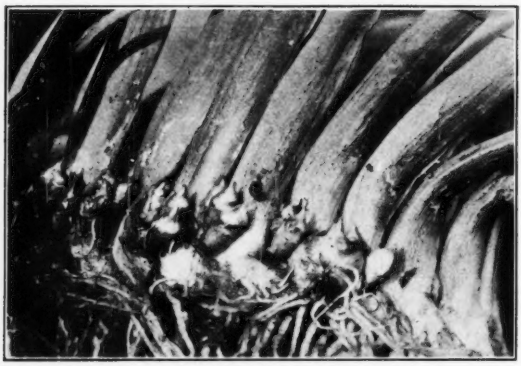

Fig. 68. Rootstock of *Butomus umbellatus,* bearing numerous pea-size bulblets. This powerful means of dispersal partly accounts for the rapid conquest by this plant of the alluvial section of the St. Lawrence River. (Photo Marie-Victorin).

it has refreshed the rather dull purple of *Lythrum Salicaria*, and painted anew the shoals with the mass effect of multitudinous pink umbels (Figs. 66, 67 and 68).

The two legions have now taken such a hold on the royal waterway of the St. Lawrence, that the Indians of old, keen observers of nature, would feel entirely estranged, would they return to paddle their canoes again along the miles and miles of *Lythrum Salicaria* and *Butomus umbellatus*.

The Flowering Rush is now entering Lake Champlain, and the Great Lakes by way of Lake Erie. Some day, through canals, it will reach the Mississippi, and the ecology of the Father of Waters will be upset.

Notwithstanding the law of Death, there is a tremendous aggressiveness in that wild fire called Life. Because of motors, of radios and the like, because of our knowledge of hormones, vitamins and enzymes, we think we have mastered Nature. Of course not! The story is simply this. A strange animal called *Homo sapiens* endowed with eminent spiritual powers, has thrown pebbles in the pond, causing concentric wave-rings to ride the mirror of Time eternal. But man has already outwitted himself. When very soon geologically speaking, *Homo sapiens* will be just another extinct species, the old balance of life will inevitably settle again, barely altered by the past wanderings of that forgotten mammal called Man. The plants of prey, for millenniums curbed and overcome by human effort, will emerge to liberty, and resume their attack with restored vigor against our abandoned fields and cities. The age-old offensive alliance of Life and Erosion will obliterate all human traces from the face of the Earth. But it will not be the end of all! On the cooled ashes of what was once the home of Mankind, in the awe of the great cosmic silence, the flaming torch of Life will nevertheless continue to brighten the World!

REFERENCES

ALCOCK, FREDERICK J. 1924—Across Gaspé. Geogr. Review **14**(2):197-214.

CARTIER, JACQUES. 1924—The Voyages of Jacques Cartier. Published from the originals with translations, notes and appendices, by H. P. Biggar. Ottawa, 330 pages.

CLÉONIQUE-JOSEPH, FRERE. 1936—Etudes de développement floristique en Laurentie. Contrib. Lab. Bot. Univ. Montréal **27**:246 pp.

COLEMAN, A. P. 1925—Physiographie et géologie glaciaire de la péninsule de Gaspé. Québec. Canada. Ministère des Mines (Commission géologique). Bull. **34** (Série géologique **41**):54 pp.

———1926—Ice Ages, Recent and Ancient. New York, Macmillan, 296 pp.

———1926—The Pleistocene of Newfoundland. Journ. Geol. **34**(3):193-223.

———1927—Glacial and Interglacial Periods in Eastern Canada. Journ. Geol. **35** (5):385-403.

———1922—Physiography and Glacial Geology of Gaspe Peninsula, Quebec, Canada. Dept. of Mines. Bull. **34**: 52 pp.

FERNALD, M. L. 1907—The soil preferences of certain alpine and subalpine plants. Rhodora **9**:149-193.

———1915—Some new or unrecorded Compositae chiefly of Northeastern America. Rhodora **17**: 17.

———1924—Isolation and endemism in Northeastern America and their relation to the age-and-area hypothesis. Amer. Journ. Bot. **11**:558-572.

———1925—Persistence of plants in unglaciated areas of boreal America. Mem. Gray Herbarium 2. Reprinted from Mem. Amer. Acad. Arts and Sci. **15**:241-342.

———1925—Two new Epilobiums of Eastern America. Rhodora **27**:32-34.

———1926—The antiquity and dispersal of vascular plants. Quart. Rev. Biol. **1**:212-245.

———1929—Some relationships of the floras of the Northern Hemisphere. Proc. Intern. Congress Plant Sci. **2**:1487-1507.

———1933—Recent discoveries in the Newfoundland flora. Rhodora **35**, Nos. 409-420 (12 parts).

GATES, R. RUGGLES. 1936—Genetical and taxonomic investigations in the genus Oenothera. Philos. Trans. Roy. Soc. London, Ser. B **226**(536):239-355.

MARIE-VICTORIN, FRERE. 1925—Sur quelques Composées nouvelles, rares ou critiques du Québec oriental. Contrib. Lab. Bot. Univ. Montréal **5**: 18 pp.

———1928—Deux épibiotes remarquables de la Minganie. Contrib. Lab. Bot. Univ. Montréal **12**: 20 pp.

———1929—Additions aux Cypéracées de l'Amérique du Nord. Contrib. Lab. Bot. Univ. Montréal **15**: 16 pp.

———1929—Le dynamisme dans la flore du Québec. Contrib. Lab. Bot. Univ. Montréal **13**: 89 pp.

———1932—Quelques plantes nouvelles ou reliquales du bassin de la baie des Chaleurs. Contrib. Lab. Bot. Univ. Montréal **20**: 22 pp.

———1935—Flore laurentienne. Montréal, Imprimerie De La Salle, 917 pp.

———1935—The vanishing flora of Quebec. 27th Annual Rep. Quebec Soc. Protection of Plants **1934-1935**:16-46.

POTTER, DAVID. 1932—Botanical evidence of a post-Pleistocene marine connection between Hudson Bay and the St. Lawrence Basin. Rhodora **34**:69-89;101-112.

ROUSSEAU, JACQUES. 1932—Contribution à l'étude du Gentiana Victorinii. Contrib. Lab. Bot. Univ. Montréal **23**: 7 pp.

———1933—Les Astragalus du Québec et leurs alliés immédiats. Contrib. Lab. Bot. Univ. Montréal **24**: 66 pp.

SAINT-CYR, D. N. 1886—Rapport du Département de l'Instruction publique (Province de Québec) transmis le 20 mai 1886. No. **17**B: 139 pp.

ST. JOHN, HAROLD. 1922—A botanical exploration of the North shore of the Gulf of St. Lawrence including an annotated list of the species of vascular plants. Canada. Dept. of Mines. Mem. **126**, no. 4 (Biological series): 130 pp.

SCHMITT, JOSEPH. 1904—Monographie de l'île d'Anticosti. Thèses Fac. Sci. Paris, Sér. A, no. **468** (No d'ordre 1195). Paris, Plon-Nourrit, 367 pp.

TWENHOFEL, W. H. 1926—Geology of the Mingan Islands. Bull. Geol. Soc. America **37**(4):535-550.

———1928—Geology of Anticosti Island. Geol. Surv. Can. Mem. **154**: 481 pp.

WRIGHT, W. B. 1937—The quaternary ice age. Toronto, Macmillan, 478 pp.

WYNNE-EDWARDS, V. C. 1937—Isolated arctic-alpine floras in Eastern North America: a discussion of their glacial and recent history. Trans. Roy. Soc. Canada. Ser. III (Sect. V) **31**: 26 pp.

The Vegetation of Muskogee County, Oklanoma

Elbert L. Little, Jr.[1]

This is the fourth of a series of papers forming a botanical survey of Muskogee County, Oklahoma (Little, 1929-1930). Articles on the bryophytes (1936), pteridophytes (1933), and seed plants (1938) have been published. The study of the vegetation of Muskogee County was made in July-October 1929.

Muskogee County covers an irregular, gerrymandered area of 826 square miles and 50 miles in greatest length in northeastern Oklahoma within the limits of 35° and 36° north latitude and 95° and 96° west longitude. The county seat and principal city is Muskogee.

Physiography, Geology, and Soils

This county is included in topographic maps of the Muskogee, Okmulgee, and Sansbois quadrangles made by the U. S. Geological Survey. The geology of Muskogee County has been described by Taff (1906) and by Soyster and Taylor (1928), and a soil survey of the county has been made by the former U. S. Bureau of Soils (Jones, 1916).

Physiographically, Muskogee County may be divided into two regions separated roughly by the Arkansas River: the Ozark region in the northeastern part of the county and the prairie plains region. The Ozark region, which is at its western limit here, consists of wooded uplands or "mountains" with steep rocky slopes and nearly level crests. The prairie plains region has a rolling to nearly level topography underlain chiefly by shales but broken by occasional flat-topped hills which are erosional remnants of sandstone. Elevation varies from about 450 feet to above 1,000 feet above sea level. Arkansas River, the largest river in the State, runs through the county, where it has a broad flood plain with terraces. Its largest tributary, Canadian River, forms a part of the southern border of the county.

Geological formations outcropping in Muskogee County are sedimentary, consisting of sandstones, shales, and limestones of Mississippian and Pennsylvanian age. Limestone outcrops are limited to small areas on hillsides in the Ozark region in the northeastern part of the county, where they form low cliffs. The outcropping bedrock of the rest of the county is of shales and sandstones. Near the Arkansas and Canadian rivers are terrace deposits of gravel and sand of Pleistocene age, and recent alluvial deposits occur along the streams.

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1 Now a member of the research staff of the Southwestern Forest and Range Experiment Station, which is maintained at Tucson, Ariz., by the Forest Service, United States Department of Agriculture, in cooperation with the University of Arizona.

The soils of Muskogee County are residual except for alluvial soils along the streams. Silt loams and sandy loams are most extensive, according to the soil survey here.

Climate

Muskogee County has a climate intermediate between that of the forested eastern part of the United States and that of the grassland of the interior. Climatological data compiled by the U. S. Weather Bureau (1930) at four stations in the county are summarized below.

Average annual precipitation is 35.96 inches at Bacone, 38.05 inches at Fort Gibson, 41.35 inches at Muskogee, and 42.12 inches at Webbers Falls. However, the annual total has varied from 19 to 66 inches. Although fairly evenly distributed throughout the year, rainfall is slightly greater during the growing season. April, May, and June have the highest averages of the different months, and December, January, and February the lowest. Average annual snowfall at three stations is 6.6 inches.

Average annual temperature at two stations in Muskogee County is 61.1° F. July and August, the hottest months, have an average temperature of 81.6°, and January, the coldest month, has an average temperature of 38.8°. The highest temperature recorded is 114° and the lowest is -16°. Average length of the growing season is 217 days. Prevailing wind direction is from the south.

Previous Studies

Studies of the vegetation of Oklahoma have been reviewed by Bruner (1931), and the miscellaneous small collections of plants in Muskogee County have been summarized by Little (1938). Although there has been no previous attempt to describe the vegetation of Muskogee County, a few brief notes have been made, principally in reports of early expeditions and surveys. The favorable location on the Arkansas River and the establishment of Fort Gibson, second oldest American settlement in the State, here in 1824 brought various explorers, visitors, and settlers into the present area of Muskogee County.

Thomas Nuttall (1821), the first botanist to visit Oklahoma, was in Muskogee County in 1819. Besides collecting specimens of a number of new species, he published valuable notes on the vegetation along his route.

As a result of the land surveys made before 1900 in Indian Territory, now eastern Oklahoma, Fitch (1900) prepared a detailed map showing the extent of woodland in this area. This map shows the distribution of forests and unforested lands (prairie except for cleared areas of flood plain) in what is now Muskogee County. Lists of common names of the characteristic tree species in each township, as given by surveyors, are included in this respect.

The most detailed description of the vegetation of Oklahoma is by Bruner (1931). In his map of the vegetation of the State, three types are shown in Muskogee County: oak-hickory association, oak-hickory savannah, and Andropogon associes. Whitaker and Osborn (1937) in a more recent compiled vegetation map of Oklahoma recognize the same three types.

Factors Affecting Vegetation

Muskogee County has been a land area continuously since the Pennsylvanian period of the Paleozoic era, and the origin and evolution of the early land flora here are unknown. At the time of maximum advance in the Kansan epoch, the Pleistocene ice sheet of northern North America was more than 200 miles north of this county.

At present Muskogee County is in the transition area between the oak-hickory forest and prairie and thus has the two climatic climax associations. Gradual climatic changes affecting vegetation doubtless have occurred in the past. With fluctuations of climate, the forest-prairie transition zone probably has shifted east and west.

Within Muskogee County, distribution of the two climatic climaxes along their border is controlled largely by physiographic factors. The oak-hickory forest occurs on sandstone hills and prairie on soils derived from shale. The limestone outcrops are occupied by an edaphic climax or postclimax, the Acer-Quercus forest association. On flood plains two associations are extensive, the Ulmus flood-plain forest subclimax association and the Salix-Populus association.

In a vegetation map of the county made by the author, four types were mapped: prairie, oak-hickory forest, maple-oak forest, and flood-plain forest. The distribution of these types on their different, characteristic substrata is so striking that a combined geological and topographic map would serve almost equally well as a vegetation map.

Man, of course, has produced changes in the vegetation, although these disturbances are probably less than in many parts of the country which have been settled longer. As a part of Indian Territory, the lands were long withheld from private ownership. Cultivation and pasturage have since destroyed much of the original vegetation.

The flood-plain forests have been almost completely destroyed and the lands placed under cultivation. Upland forest areas that have not been cleared are grazed to a certain extent and some of these are burned over annually by surface fires.

Although the native prairies have been disturbed by man through cultivation and overgrazing, surprisingly large areas of unbroken prairie sod remain. These areas are cut annually for hay and sometimes burned over afterwards. Where the prairies have been fenced into pastures, overgrazing has occurred in most cases and the original vegetation has been succeeded by ruderals.

The Climax Associations

In the description of the vegetation of Muskogee County the outline followed will be: (1) the climax associations, including the Quercus-Carya climax forest association, the *Andropogon furcatus* climax prairie association, the Acer-Quercus forest association, and the Ulmus flood-plain forest association; and (2) the physiographic successions, including (a) the primary xerarch successions on sandstone, shale, and limestone; (b) the secondary xerarch suc-

cessions due to grazing, clearing, and cultivation; and (c) the primary hydrarch successions of ponds and of streams on silt, sand, gravel, and alkali. More detailed descriptions with photographs and lists of species are contained in the author's unpublished study (Little 1929-1930).

Quercus-Carya Climax Forest Association

The Quercus Carya climax forest association occurs chiefly on the sandstone outcrops, which form the hills. It is most extensive in the part of Muskogee County east of the Arkansas River but also is present in more or less scattered patches on sandstone hills in the prairie area of the county.

As it is nearing its western limit, the oak-hickory forest is much less luxuriant than eastward where the rainfall is greater and evaporation relatively less. It is a low open deciduous forest frequently with a grassland floor (Fig. 1). The crooked, low spreading trees average 25 to 40 feet high and up to 1 foot or more in diameter, but on the slopes the trees are larger. Commercially this is of greatest value for woodlots, pastures, and erosion control. Some areas have been cleared and cultivated, but the soil is thin and rocky.

The oak-hickory forest here corresponds to type 31, post oak - blackjack oak, of the Society of American Foresters (1932). Dominant species are: *Quercus marilandica,* blackjack oak; *Q. stellata,* post oak; *Carya alba,* mockernut hickory, and *C. buckleyi,* black hickory. Other characteristic tree species are *Quercus shumardii, Q. velutina,* and *Ulmus alata.* In the southern part of the county, *Pinus echinata,* shortleaf pine, locally forms a conspicuous element in this type on sandstone rocky slopes and ridges.

Rhus copallina and *R. glabra* are characteristic shrubby species of this open forest. Herbaceous species commonly represented include: *Paspalum muhlenbergii, Panicum* spp. (subgenus *Dichanthelium), Schrankia uncinata, Antennaria plantaginifolia,* and *Helianthus hirsutus.*

Andropogon Furcatus Climax Prairie Association

The *Andropogon furcatus* climax prairie association was originally the most extensive association in Muskogee County, occurring over nearly all the area of the county west of the Arkansas River and covering a greater area than all the forest types combined. It occupies the well-drained rolling or nearly level areas which are underlain by shales.

Tall perennial grasses are characteristic of this tall-grass prairie. Three plant families, Compositae, Gramineae, and Leguminosae, which together contain one-third of the vascular species of the county, are especially well represented in the prairie. A few woody plant species are represented in small numbers.

Andropogon furcatus, bluejoint turkeyfoot or big bluestem, is the dominant species. It has an average height of about 4 to 6 feet, but plants up to 8 feet tall were noted (Figs. 2, 3). Characteristic associated species of grasses are: *Andropogon scoparius, Koeleria cristata, Manisurus cylindrica, Panicum virgatum, Panicum* spp. (subgenus *Dichanthelium), Paspalum floridanum,* and *Sorghastrum nutans.*

Other characteristic prairie herbaceous species include: composites, *Achillea lanulosa, Aster multiflorus, Helianthus mollis, Liatris pycnostachya, L. scariosa, Rudbeckia hirta, R. grandiflora,* and *Silphium laciniatum;* legumes, *Amorpha canescens, Baptisia bracteata, Petalostemum candidum, P. purpureum,* and *Schrankia uncinata;* and *Eryngium yuccifolium, Ruellia ciliosa, Sabatia campestris,* and *Salvia azurea* var. *grandiflora.*

A quantitative study of prairie vegetation made by means of the list quadrat method showed that the composition varies somewhat in different areas. In each of 5 representative areas 25 list quadrats 1 meter square and 5 meters apart in a straight line were taken in July 1929 before the larger prairie grasses were in flower. Frequency indices were determined by the percentage of quadrats in which plants of a given species were rooted. A total of about 104 species were represented on the strips in which quadrats were located, but a few of these did not occur on the quadrats.

Species with frequency indices above 10 percent are listed below with their frequency indices:

Grass cover of *Andropogon furcatus,* etc.	100
Panicum spp. (subgenus *Dichanthelium*)	63
Ruellia ciliosa	60
Petalostemum candidum	58
Aster multiflorus	58
Oxalis stricta	51
Petalostemum purpureum	34
Achillea lanulosa	34
Koeleria cristata	32
Erigeron ramosus	31
Fimbristylis castanea var. *puberula*	29
Coreopsis tinctoria	28
Solidago missouriensis	28
Polygala verticillata	26
Ptilimnium nuttallii	26
Rudbeckia hirta	26
Lespedeza stuvei var. *neglecta*	21
Amorpha canescens	18
Psoralea tenuiflora	18
Manisurus cylindrica	16
Scleria ciliata	13
Asclepiodora viridis	13
Plantago elongata	13
Strophostyles pauciflora	12
Euphorbia corollata	12
Tragia sp.	12
Scutellaria parvula	11

Short-grass or plains vegetation, which is characteristic of western grasslands and which is becoming more abundant eastward on overgrazed tallgrass areas, is not found as far east as Muskogee County. The author collected plants in this county five years before he finally found a few rare plants of *Bouteloua hirsuta,* a characteristic short-grass species, on a south-facing hillside.

Acer-Quercus Forest Association

The Acer-Quercus forest association is a mesophytic forest of restricted occurrence in Muskogee County at its western limit. This maple-oak forest is an edaphic climax or postclimax limited to limestone outcrops on hillsides of the Ozark region in the eastern part of the county, especially on Bragg Mountain. It is an extension of the more mesophytic deciduous forest of the Ozarks, which would be included in type 49, white oak - black oak - red oak, of the Society of American Foresters. The maple-oak forest is of limited extent here at the western border of the Ozarks, where *Acer saccharum* extends farther westward than the typical associated tree species, such as *Quercus alba, Acer rubrum,* and *Tilia floridana,* which reach their western limit less than 15 miles east of this county.

This forest is a richer and denser deciduous forest than the oak-hickory forest. Its trees are larger, averaging 40 to 60 feet in height, its canopy is denser, and its undergrowth is more mesophytic and contains more eastern shade herbs (Fig. 4).

The dominant species are: *Acer saccharum,* sugar maple, which reaches the western limit of its range here, except for disjunct patches in the Caddo County canyons 175 miles westward: *Quercus muhlenbergii,* chinquapin oak; and *Quercus shumardii,* Shumard red oak. Other tree species of this forest include those of the oak-hickory forest as well as more mesophytic species, such as *Celtis laevigata, Gymnocladus dioica,* and *Fraxinus americana.* Among the shrubby species are *Benzoin aestivale, Ptelea trifoliata, Rhus canadensis,* and *Ilex decidua.* Eastern shade herbaceous species include *Anemone virginiana, Silene stellata, Podophyllum peltatum, Phryma leptostachya, Triosteum aurantiacum,* and *Campanula americana.*

Ulmus Flood-Plain Forest Association

The Ulmus flood-plain forest association on higher levels of silt flood plains may be regarded as an edaphic or subclimax forest. It is the richest forest of the county and would not likely be succeeded by the upland climatic climax types unless great changes in moisture, such as lowering of the water table, would occur.

Because the soils occupied by this forest are the most productive for agriculture in this region, the flood-plain forest has now been almost entirely destroyed except for scattered trees and small patches and replaced by crops, principally potatoes and cotton. Undoubtedly some large and valuable hardwood logs were obtained when these areas were cleared before 1900.

Nuttall's (1821) notes on the original flood-plain forest of Muskogee County in 1819, are of special interest. The smooth-barked cottonwood, elm, box-elder, curled maple, ash, scarlet oak, and hackberry were mentioned in his journal. He walked over a portion of the alluvial land, "the fertility of which was sufficiently obvious in the disagreeable and smothering luxuriance of the tall weeds, with which it was overrun. This neck of land . . . is about two miles wide, free from inundation, and covered with larger trees than any other

I had seen since leaving Fort Smith." He noted also "a thick canebrake, more than two miles in width," which long since has given way to cultivated fields. In 1807 Lieut. J. B. Wilkinson (Pike, 1810), first American explorer in Oklahoma, also mentioned cane generally lining the banks of the Arkansas River in what is now Muskogee County.

The Ulmus flood-plain forest association is a deciduous forest averaging 50 to 70 feet in height and varying somewhat in composition of the common tree species (Fig. 5). The large deciduous trees form a close canopy which shades the undergrowth. Lianas (chiefly members of *Vitaceae* and *Smilax* spp.) are especially numerous. The herbs of the forest floor are mesophytic shade plants which mostly are late in starting growth but grow rapidly and flower in late summer.

This forest seems nearest to type 60, silver maple - American elm, in the classification of the Society of American Foresters. Dominant species of the Ulmus flood-plain association are *Ulmus americana,* American elm, and *U. fulva,* slippery elm. Other tree species, especially oaks and hickories, are well represented but vary in composition from place to place. These include: *Carya cordiformis, C. illinoensis, Juglans nigra, Quercus borealis, Q. macrocarpa, Q. nigra, Q. shumardii, Celtis laevigata, C. occidentalis, Maclura pomifera, Ulmus alata, U. crassifolia, Morus rubra, Platanus occidentalis, Gleditsia triacanthos, Gymnocladus dioica, Acer negundo, A. saccharinum, Sapindus drummondii, Cornus florida, Bumelia lanuginosa,* and *Fraxinus pennsylvanica.*

Woody species commonly represented in the undergrowth are: *Arundinaria tecta, Crataegus viridis, Cercis canadensis, Cornus asperifolia, Sambucus canadensis,* and *Symphoricarpos orbiculatus.* Among the herbaceous species most commonly resented in the Ulmus flood-plain association are *Dicliptera brachiata* and *Ruellia strepens.* In open areas of the flood plain are dense growths of tall annual herbs, chiefly of the species *Ambrosia trifida* and *Xanthium speciosum.* Plants of the former species reach a height of 10 to 12 feet and those of the latter 6 feet.

The Physiographic Successions

Primary Xerarch Successions

The xerarch successions are mainly those of rock outcrops of sandstone, shale, and limestone. Although the successions are slightly different on the three kinds of bedrock, the primary xerarch sucecssion includes the following stages: a lichen-moss association, a xerophytic herb association, and a shrub association followed by one of the three upland climax associations, depending upon the kind of bedrock. Apparently in many cases one or more of the above associations have been omitted in the succession.

Sandstone. — Sandstone outcrops with primary xerarch successions occur in the oak-hickory forest and forest-prairie transition areas where they form cliffs of resistant rock and boulders. On bare sandstone bluffs in oak-hickory forest areas the pioneer association is the lichen-moss association of crustose and foliose lichens and mosses, especially those of the species *Grimmia campestris* and *Hedwigia albicans.* In the xerophytic herb association of rocky soil *An-*

dropogon scoparius is characteristic. The shrub stage is represented by the Rhus association of *Rhus glabra* and *R. copallina*. As more soil is formed the oak-hickory forest becomes established.

The separation between the oak-hickory forest and prairie is usually not a sharp one. On sandstone hillsides between forest and grassland and isolated in the prairie there are usually areas of shrubs and low trees (Fig. 6). Partly, at least, the transition vegetation consists of pioneer stages in the primary xerarch succession to the two climaxes. Some of the stages may be omitted in places.

The lichen-moss association occurs on sandstone outcrops at the tops of the hills. The next stage, the *Andropogon saccharoides* pioneer herb association, is found on rocky slopes and shallow soil. *Andropogon saccharoides* is the dominant species and *Houstonia angustifolia* and *Plantago aristata* common pioneers. The Rhus association of shrubs 3 to 5 feet high with *Rhus copallina* and *R. glabra* dominant occupies more extensive similar areas. The Diospyros association of a thicket of small trees 10 to 15 feet high with *Diospyros virginiana,* persimmon, dominant occurs on the slopes and along the bluffs.

The Ulmus ravine association with *Ulmus alata* and *U. americana* dominant is a mesophytic forest of trees up to 30 or 40 feet high and 1 foot or more in diameter restricted to moister areas in ravines on the hillsides and on north-facing slopes. This forest is more mesophytic than the oak-hickory forest and is essentially the same as the Ulmus flood-plain forest of the stream valleys but composed of smaller trees of fewer species.

All the successional relationships of these associations to the two climaxes are not clear. The lichen-moss association is a pioneer association on bare sandstone outcrops. The *Andropogon saccharoides* pioneer herb association, the first association on rocky soil, is succeeded by the Rhus shrub association and probably also by the *Andropogon furcatus* climax association.

The Rhus shrub association and Diospyros association apparently have been in many cases pioneer associations in crevices along the cliffs, although in other places they probably have succeeded the pioneer herb association. The *Andropogon furcatus* climax prairie association may succeed the Rhus shrub association on areas of more shale than sandstone where a deeper loam soil is formed. The oak-hickory climax forest association probably may succeed any of the successional associations directly.

Shale. — Beginning with a bare shale outcrop the succession leads usually to the *Andropogon furcatus* climax prairie. As poorly consolidated shale weathers rapidly into a soil, the outcrops of shale rock are limited. The lichen-moss association is absent and the pioneer plants are members of the xerophytic herb association. On small areas of barren clay soil, usually in the prairie area, the pioneer association is the *Aristida oligantha* association with *Aristida oligantha* dominant.

Limestone. — The xerarch succession on limestone leads from limestone bluffs and rocky slopes to the maple-oak forest edaphic climax. The bare rock faces are mostly covered with mats of crustose and foliose lichens and bryo-

phytes of the lichen-moss association. *Grimmia apocarpa* is the dominant species of moss here. On crevices and shelves the xerophytic herb association of ferns and seed plants, especially *Parietaria pennsylvanica,* is present. Shrubs and trees of the climax forest later become established.

Secondary Xerarch Successions

Secondary xerarch successions following disturbances by man of the primary successions in Muskogee County are of three main types: due to grazing, due to clearing, and due to cultivation.

Due to grazing. — As a result of overgrazing of prairie and oak-hickory forest areas the original herbaceous vegetation has been replaced by herbs not eaten by livestock until the areas have become almost worthless as pastures. Nearly all the pastures of the county have a vegetation of ruderal associations.

These ruderals are chiefly native species which as a result of elimination of grasses by overgrazing have rapidly increased in numbers and occur in almost pure stands in extreme cases of overgrazing. The following are herbaceous species most commonly indicative of overgrazing: *Ambrosia bidentata, A. psilostachya, Amphiachyris dracunculoides, Eupatorium serotinum, Helenium tenuifolium,* and *Solidago gymnospermoides,* all composites; and *Ptilimnium nuttallii,* an umbellifer (Fig. 2).

One of the above species is dominant in the ruderal association in each case and usually much more commonly represented than the others, although all seem to be ecologically equivalent. *Helenium tenuifolium* is the most abundantly represented of these indicators of overgrazing here. If grazing animals were kept out of overgrazed areas, it is probable that the original vegetation would replace the ruderal associations within a reasonably short time.

Due to clearing of forests. — The oak-hickory forest succeeds itself directly when cut, by sprouts from the roots of the cut trees. The maple-oak forest is succeeded after clearing by a shrub association which is probably replaced later by the forest.

Due to cultivation. — Where the native vegetation has been destroyed by man and replaced by cultivated crops and then cultivation abandoned, ruderal associations of herbs take possession. These ruderal associations consist partly of weeds introduced at the time of cultivation and partly of native species.

Digitaria sanguinalis, an annual introduced grass, and *Erigeron canadensis,* an annual native composite, are the dominant species of their respective ruderal associations. With them are other more or less common weeds of cultivated fields. It is probable that these ruderal associations if left undisturbed would be succeeded in time by the original vegetation.

Primary Hydrarch Successions

Ponds. — The hydrarch successions of Muskogee County may be divided into two groups, those of ponds and those of streams. The common type of pond is the shallow, artificial pond constructed in the prairie by damming a

drainage to provide water for livestock. Although they are of man's origin, the ponds of the prairie have a hydrarch succession which appears to be a natural one. There are also a few ox-bow lakes in flood plains of the Arkansas and Canadian rivers.

Zonation is more clearly marked in the pond succession than in any others in the county. The common succession of the ponds contains these associations: *Jussiaea diffusa* association, Juncus-sedge association, Bidens-Boltonia association, and Salix-Populus association.

The ponds of Muskogee County do not have a well developed aquatic vegetation, and the flora is especially poor in aquatic seed plants. Except for green algae, the first association of prairie ponds is ordinarily the *Jussiaea diffusa* association, consisting of a floating mat of *Jussiaea diffusa* extending over the surface from the edge (Fig. 7). The next stage is represented by the Juncus-sedge association in shallow water and on moist soil at the edge of the ponds. Dominant species are: *Juncus robustus, J. diffusissimus, Cyperus pseudovegetus, Eleocharis obtusa,* and *Rynochospora macrostachya.*

On slightly higher soils occurs the Bidens-Boltonia association of taller herbs. *Bidens involucrata* and *Boltonia latisquama,* the dominant species, are composites, but sedges and rushes are also present. This association usually merges into the climax prairie of the upland succession, or there may be a border of scattered shrubs and trees of the Salix-Populus association, represented by *Salix nigra* and, less commonly, *Populus deltoides* and *Cephalanthus occidentalis.* In some cases the herbaceous associations are absent and the ponds are bordered by this association of woody species.

There are minor variations in the pond succession. In some ponds the Typha association with *Typha latifolia* dominant is the pioneer seed plant association. Another pioneer association which sometimes occupies the whole area of shallow ponds is the Sagittaria association of *Sagittaria ambigua* and *S. latifolia.* The Typha and Sagittaria associations are succeeded commonly by the Juncus-sedge association.

Streams. — Hydrarch successions of streams are best developed along the Arkansas and Canadian rivers, which have flood plains one to two or more miles wide. The silt type of flood plain is commonest along the Arkansas River while the sand flood plain is commonest along the Canadian River. Small areas of gravel flood plain are found also.

Silt. — On the silt flood plain of the Arkansas River two associations are fairly well defined: the Salix-Populus association and the Ulmus flood-plain association. The former occurs next to the river on the lower levels, which are inundated usually every spring, while the latter occupies the higher and more extensive portions of the flood plain.

The Salix-Populus association corresponds with type 88, willow, and type 60, cottonwood, of the Society of American Foresters. It is a forest of trees 30 to 50 feet high with *Salix nigra,* black willow, and *Populus deltoides,* eastern cottonwood, dominant. A row of trees of *Salix nigra* usually lines the banks and leans over the water. Trees of *Populus deltoides* are common on slightly higher levels and become, with trees of *Platanus occidentalis* here, the

largest trees of the county. Other tree species of this association are: *Acer saccharinum, Forestiera acuminata,* and *Fraxinus pennsylvanica.* Because of annual submergence there is almost no undergrowth. Where the level of the flood plain has been raised by silt deposits the Salix-Populus association has been succeeded by the Ulmus flood-plain association.

Along smaller streams the Populus-Salix association is represented by marginal trees, chiefly of *Salix nigra,* or is absent. The Ulmus flood-plain association here is less luxuriant. Higher up toward the sources of streams in the prairie, species of the flood-plain forest gradually drop out until along the small intermittent tributaries no trees are present and the prairie climax borders on the narrow stream beds. Among the woody plants extending farthest up into the prairie are those of *Crataegus viridis* and *Symphoricarpos orbiculatus.* In places grasses of the species *Spartina pectinata* border intermittent prairie streams.

Sand. — On the sand flood plain of the Canadian River the Salix- Populus association is characteristic (Fig. 8). Seedlings of the dominant species, *Salix longifolia* (sandbar willow), *S. nigra,* and *Populus deltoides,* germinate on moist sand which has been recently deposited or denuded. Within a few years this association consists of scattered or dense shrubs of the dominant species. In open sandy areas the common herbaceous species are: *Cassia chamaecrista, Strophostyles helvola, Euphorbia petaloidea, Oenothera rhombipetala,* and *Heliotropium convolvulaceum.* With the growth in size of members of the dominant species, this association becomes a forest 40 to 50 feet high similar to the Salix-Populus association on silt.

Gravel. — The limited areas of gravel flood plain have a vegetation of the Salix-Populus association in places. On one annually flooded gravel deposit of the Arkansas River, there is a herbaceous association in which *Amsonia tabernaemontana* is dominant.

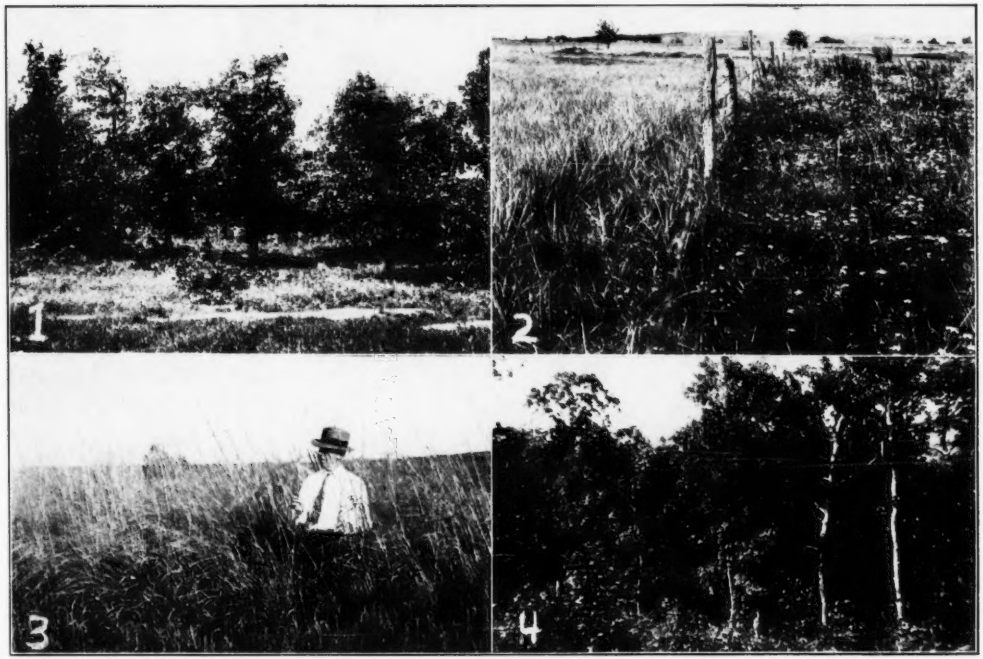
Alkali. — Along a few intermittent streams of the prairie are limited areas of white alkali. These small areas are plantless except near the edge where there is a herbaceous association of *Polygonum ramosissimum* with a few other alkali tolerant species. Small plantless areas where salt water and oil from oil wells have destroyed the vegetation are bordered also by a zone of *Polygonum ramosissimum.*

Summary

Muskogee County is located in northeastern Oklahoma in the forest-grassland transition zone and has two climatic climaxes, the Quercus-Carya climax forest association and the *Andropogon furcatus* climax prairie association. The former is an open deciduous forest occurring on sandstone outcrops. The latter, on areas underlain by shale, consists of tall grasses and other herbs, among which composites and legumes are conspicuous.

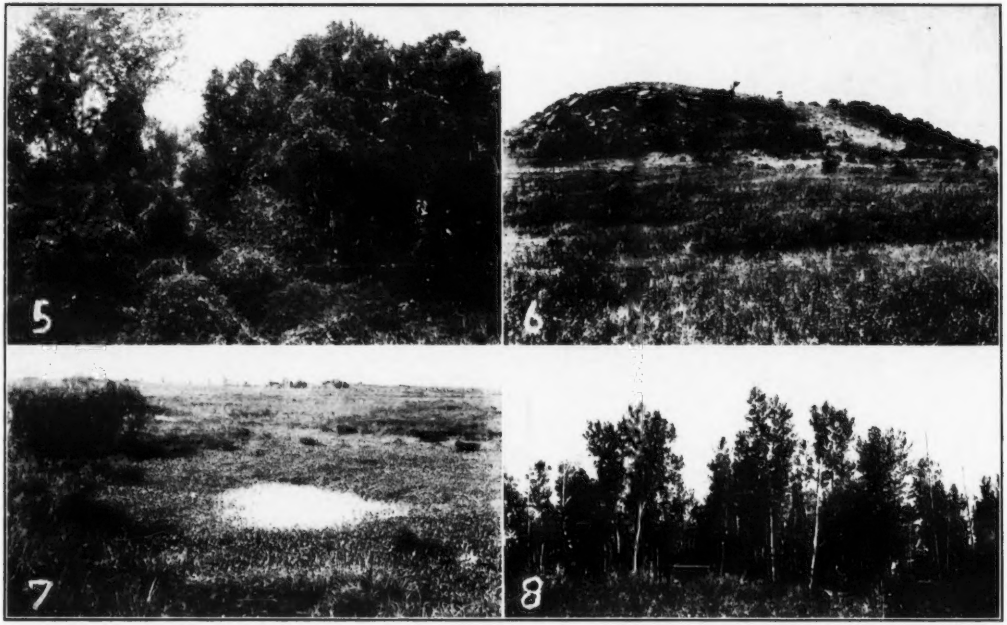
The Acer-Quercus forest association is an edaphic climax or postclimax of limited extent on limestone outcrops. On flood plains the Ulmus flood-plain forest association is an edaphic climax or subclimax.

Physiographic successions to the climaxes are described.



Figs. 1-4: (1)Open oak-hickory forest of low spreading trees. (2) *Andropogon furcatus* association in July before maturity of grasses, at left, and *Ptilimnium nuttallii* ruderal association of overgrazed prairie at right, separated by fence. (3) *Andropogon furcatus* prairie in October with plants of *Andropogon furcatus* at maturity 7½ to 8 feet high. (4) Maple-oak forest on limestone in the Ozark region.

left, and *Ptilimnium nuttallii* ruderal association of overgrazed prairie at right, separated by fence. (3) *Andropogon furcatus* prairie in October with plants of *Andropogon furcatus* at maturity 7½ to 8 feet high. (4) Maple-oak forest on limestone in the Ozark region.



Figs. 5-8: (5) Partially cut Ulmus flood-plain forest near Arkansas River, with lianas covering tops of trees and shrubs. (6) A sandstone hill with the forest-prairie transition vegetation, looking west. The vegetation is mainly of the Rhus and Diospyros associations with the Ulmus ravine association on the north-facing slope. Prairie in foreground. (7) Artificial pond in prairie, showing *Jussiaea diffusa* association almost covering pond and at border the Juncus-sedge and Salix-Populus associations. (8) Salix-Populus association on sand flood plain of Canadian River.

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REFERENCES

BRUNER, W. E. 1931—The vegetation of Oklahoma. Ecol. Mon. **1**:99-188.

FITCH, C. H. 1900—Woodland of Indian Territory. U. S. Geol. Surv. Ann. Rept. **21**(5):603-672, pl. CXLII.

JONES, GROVE B., CORNELIUS VAN DUYNE, EWING SCOTT, AND H. W. HAWKER. 1916—Soil survey of Muskogee County, Oklahoma. U. S. Dept. Agr., Bur. Soils, Field Operations of the Bureau of Soils, **1913**: 1853-1891 and map.

LITTLE, ELBERT L., JR. 1929-1930—A botanical survey of Muskogee County, Oklahoma. Unpubl. thesis, Univ. Chicago, 1929. Abstract published: Univ. Chicago, Abstracts of Theses, Sci. Ser. **8**:223-226.

———1933—Pteridophytes of Muskogee County, Oklahoma. Amer. Fern Jour. **23**:91-93.

———1936—The bryophytes of Muskogee County, Oklahoma. Bryologist **39**:8-16.

———1938—Flora of Muskogee County, Oklahoma. Amer. Midl. Nat. **19**(2):369-388.

NUTTALL, THOMAS. 1821—A journal of travels into the Arkansa territory during the year 1819. Philadelphia.

PIKE, Z. M. 1810—An account of expeditions to the sources of the Mississippi. . . . during the years 1805, 1806, and 1807. Philadelphia.

SOCIETY OF AMERICAN FORESTERS. 1932—Forest cover types of the eastern United States. Journ. Forestry **30**:451-498.

SOYSTER, HALE B. AND THOS. G. TAYLOR. 1928—Oil and gas geology of Muskogee County. Okla. Geol. Surv. Bull. **40**-FF.

TAFF, JOSEPH A. 1906—Muscogee Folio No. 132. Geological atlas of the United States. 7 pp. and maps.

U. S. DEPARTMENT OF AGRICULTURE, WEATHER BUREAU. 1930—Climatic summary of the United States. Section **43**. Eastern Oklahoma.

WHITAKER, H. L. AND BEN OSBORN. 1937—Wildlife management—erosion control in the central Great Plains region. U. S. Dept. Agr., Soil Cons. Serv., Reg. 7. 63 pp. Mimeographed.

TUCSON, ARIZ.

The Species-Area Curve[1]

Stanley A. Cain

Jaccard (1912), one of the first who studied scientifically the species-area relationships, did not confine his observations to a single type of community. The areas with which he dealt were occupied by several different plant communities. His work was fruitful and plant sociologists very soon were studying the effect of the size of the stand on the number of species to be found within the community. This led to the concept of minimal area, "the smallest area which can contain an adequate representation of an association" (Braun-Blanquet, 1932, p. 52).

The question is immediately raised: What constitutes an adequate representation of an association? When is a stand (an association individual) to be considered adequate and when is it inadequate, or fragmentary? The answer varies somewhat with the different schools of plant sociology, i.e. it depends upon those aspects of community composition and structure which are emphasized. "Minima of space and number of species are certainly requirements which must be assigned to an association," says Braun-Blanquet. Not only a minimum number of species but the characteristic combination of species must occur on the area in question for the stand to be considered a minimal area. This "characteristic combination of species" would mean, for some plant sociologists, (1) the characteristic coverage of the "dominant species"; for others (2) the characteristic homogeneity of structure as shown by the "constant species," described in terms of presence, constance, and/or frequence; or (3) the presence of "characteristic species," i.e. those of high fidelity.

It is apparent, also, that the minimal area will vary greatly for different communities. It is equally obvious that this minimal area, which is said to be one of the characteristics of an association, can be determined only by empirical methods. No concept of minimal area would appear to be certain if based on only one or a few stands of the association. In other words, one must know the association well in order to know what is the "characteristic combination of species." In practice, one may assume fairly that a certain stand is representative of the association if it is extensive relative to the apparent complexity of composition and structure of the community.

The species-area curve was quickly recognized as an important tool in community description and was used as a guide in the determination of minimal area of a community. In its original form it was constructed as follows: the number of species found in an association individual (stand) is plotted on the y-axis coordinate with the area of the stand which is plotted on the x-axis. In this manner, when several association individuals of various sizes have been examined, it is found that the species-area points define a characteristic curve. This curve rises rapidly from the intersection of the y and x

1 Contributions from the Botanical Laboratory, The University of Tennessee. N. Ser. No. 23.

axes but sooner or later breaks its rate of rise and tends ultimately to become asymptote with the x-axis. The minimal area of an association is taken to be that area at which the species-area curve becomes nearly a straight line and nearly horizontal.

The work of Braun-Blanquet (Braun-Blanquet and Jenny, 1926) has done much to familiarize plant sociologists with the idea of minimal area. His species-area curve for the *Elynetum* (loc. cit., fig. 18, p. 253) is typical of this treatment. This curve, reproduced as the upper part of our Fig. 1, is based on the following data:

Area of stands in sq. m.	Number of stands	Average number of species	Extremes
0.5	15	21	12-32
1.0	5	28	25-30
4.0	10	35	30-40
20.0	2	46	45-47
c.50.0	2	56	56-57

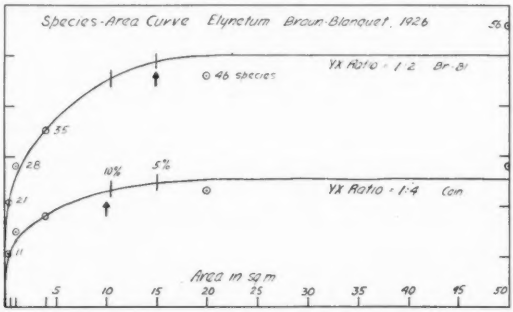


Fig. 1

The form of the curve would indicate a minimal area of 15-20 sq. m. for the Elynetum which is a community rich in species. His species-area curves for the *Festucetum Halleri* and the *Curvuletum typicum* are constructed in a similar manner (loc. cit., 1926: fig. 20, p. 265; also, 1932: fig. 33, p. 55). These curves indicate a minimal area of about 20-25 sq. m. for the *Festucetum* which is rich in species, and a minimal area of about 10 sq. m. for the *Curvuletum* which is less rich in species. The species-area curve for the *Festucetum* is illustrated by our Figure 2.

It is confusing, and apparently contradictory to the defined concept of minimal area, to find that Braun-Blanquet's sociological tables for the *Elynetum* are based on stands of areas which are all (with one exception) smaller than the minimal area for that community. His Table X (1926: p. 250) is based on stands of 1, 4, and 6 sq. m. with the exception of one large stand, and Table XI (loc. cit., p. 254) is based on 0.5 sq. m. areas. Likewise, his sociological tables for the *Festucetum* and the *Curvuletum* contain data from stands of smaller size than the minimal areas for those communities. Braun-

Blanquet (1932, p. 55) justifies this procedure by the following statement:

> If the working out of the essential properties of communities were purely a mechanical process, it would be necessary. . . . only to tabulate plots of at least the minimal area and with a correspondingly high average number of species. All smaller plots, and those with fewer species, would be disposed of as fragmentary stands (association individuals). But sometimes the normal characteristic combination of species can be verified on smaller areas, and contrariwise, it may under some circumstances remain incomplete on a plot considerably larger than the minimal area. Consequently in every record of an association taken for the purpose of tabulation it is necessary to be careful that the normal characteristic combination of species is present and that the requirements of the minimal area are approximately fulfilled.

If, however, we limit our attention to the manner in which the species-area curve for a community is constructed, we find that originally it was based on the total area of each of the different stands examined.

It is, perhaps, at this point necessary to define three terms which will be used as the discussion progresses. In the first place the species-area curves described above were based on the total number of species found on the total areas of the association individuals examined. The occurrence of a certain species on these lists (that is, of plants of the species in the various stands) is called *presence*. The "presence" of a species in an association is usually expressed as its percentile occurrence in the several stands of the association. A species needs be represented in a stand only by a single individual for its name to be found on the species list for a stand. Also, the area of the stand is not considered—the floristic lists from stands of all sizes being compared on an equal basis. As is apparent from the species-area curves, larger stands have more species. Hence each species is more likely to occur among those present in the larger stands. The idea of *constance* is similar to that of presence. But the constancy percentages of the species have more statistical validity than do presence percentages. This is because the whole area of a stand is not sampled but only a certain limited and constant area. This sample area (only one plot per stand being taken) should not be less than the minimal area for the association. The *frequence* of a species refers to its percentile occurrence on the several sample plots (quadrats) laid out within a single stand of the association.

Species-area curves are employed in the empirical determinations of the sample plot sizes to be used in obtaining constancy data for associations. Braun-Blanquet (1932, p. 56) says, "In each normally developed stand a small definitely bounded trial plot is laid out (a), then a second and third larger (b, c), and then notes are taken on the species present in the stand (d) outside the trial plots. A similar procedure may be followed in determining the species-area curve." We have thus been given a second way of constructing species-area curves and of determining minimal area. It is obvious that the procedure described above must be applied only to stands which are certainly larger than the minimal area of the association.

Two additional uses of the species-area curve in community statistics are, in so far as the author knows, a contribution of American plant sociologists. Hanson and Love (1930), Cain (1932, 1934, 1935, 1936), Fig. 3, Cain,

Nelson and McLean (1937), Fig. 4, and Penfound and Watkins (1937), Fig. 5, have used species-area curves in the study of two problems in community sampling: (1) the problem of the *size* of quadrat to be used for obtaining frequency (and other) data concerning association individuals; (2) the problem of the *number* of such minimum-area quadrats necessary for an adequate sample of the association individual.

Species-area curves from various published sources are reproduced in this paper. In each instance the data for any one community are plotted in at least two ways. That is, the data are plotted with different ratios between the y and the x axes. By way of illustration, note Fig. 2 for the *Festucetum Halleri* (Braun-Blanquet, 1926). The ratios of y to x axis are 1:2 and 1:4 approximately. The duplicate plottings of identical data are shown for the purpose of illustrating a point apparently overlooked in the literature on species-area curves—that the shape of the curve depends on the y-x ratio which the author happens to select. When these curves are inspected and one selects points to represent the minimal area (as indicated by the heavy arrows on our figures) it is found that the apparent minimal area for the *Festucetum* is 15 sq. m. in one instance and 25 sq, m. in the other. In looking over several published species-area curves one finds y-x axis ratios from approximately 1:1 (Penfound and Watkins, 1937) Fig. 5, to approximately 1:5 (Moor, 1936). The longer the x axis in proportion to the y axis the smaller the *apparent* minimal area. If the point on a species-area curve where the curve flattens strongly is to be taken as an indication of the minimal area, a procedure described by those who first used the curve for such a purpose, it becomes important what ratio is used between the y and x axes of the curve.

The most obvious proposal in this connection is that a standard relationship be employed, say a ratio of 1:3 for the y and x axes. The problem, however, needs closer scrutiny, for there are aspects of both practical and theoretical importance. One needs to know the minimal area for the purpose of discarding statistics from those association individuals which are smaller than the minimal area and hence likely to be fragmentary. Also, one needs to know the minimal area for the single plot method of association study. From this method one derives constancy and other statistical data which are directly comparable, inasmuch as they are obtained from sample plots of equal area. It becomes a valuable time and labor saving proposition to use for these purposes plots which are as small as possible, that is, of the least size consistent with adequate data and results ,Cain (1935). The theoretical aspect of the problem is that the minimal area is said to be one of the characteristics of an association. If that is true one must have some more reliable method of determining it than the shape of the species-area curve. Of course the field worker does not depend wholly on the curve but examines the sample plot to see if the "characteristic combination of species" is present.

Are we, then, to discard the species-area curve as a tool? It would seem that the curve should have some use inasmuch as it expresses certain truths about the community. Field experience has shown that the steep initial rise

of the curve indicates a sampling of those species which are most important in the community, i.e. species of high frequence, density, coverage and constance. Also, those new species represented by the gradual rise of the curve as it tends to become asymptote are ones usually of little importance in the community. One, then, should be able to select more accurately than is now the practice some point on the curve which represents minimum adequate sampling or minimal area as the case may be. The method of selecting this point should apply equally to all four of the types of uses of the curve mentioned earlier in this paper.

These considerations have given rise to the following proposal: namely, to determine the point at which the curve has a certain percentile rise. For example, select arbitrarily the proposition to determine which point on the curve represents a rate of increase of 10 per cent of the total number of species for an increase of 10 per cent of the total sample area. In the *Festucetum* (Fig. 2) the total area (on the x axis) is 100 sq. m. and the total number of species (on the y axis) is 56. The region on the curve where the above arbitrarily selected 10 per cent relationship holds will be found where 1/10 of the x axis is equal to an increase of 5.6 species (1/10 of the total number sampled). This point can be found approximately by inspection, but it can be located easily and accurately by the following mechanical device. Place the edge of a triangle at the base of the chart so that its edge passes through zero (intersection of y and x) and through the point which represents 10 per cent of the area and 10 per cent of the species. (Actually it is easier to use 50 or 100 per cent of each). Next place a ruler along the right side of the triangle and then slide the triangle up until its edge describes a tangent to the curve. That point where the tangent falls is he center of the region of the curve where the 10 per cent relationship holds. This point on

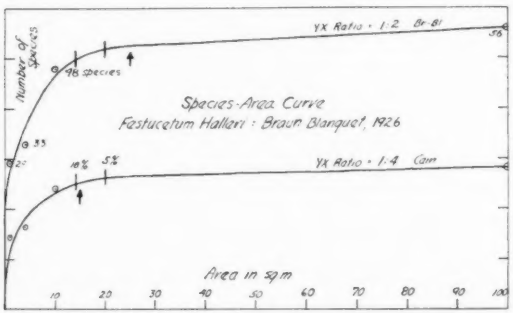


Fig. 2

the lower curve for *Festucetum* (Fig. 2), to continue our example, falls at 15 sq. m. It is practically the point selected by eye (heavy arrow) as minimal area for the curve drawn on a 1:4 ratio. The same procedure for the upper curve, Figure 2, gives the same minimal area, as indeed it must for mathematical reasons. But the point selected by eye for the minimal area on that

curve lies at about 2 per cent increase for 10 per cent of the area, or at 25 sq. m. It is also shown on the curves that the point for a 5 per cent increase lies at the 20 sq. m. area. Similar relationships are indicated in all the figures in this paper.

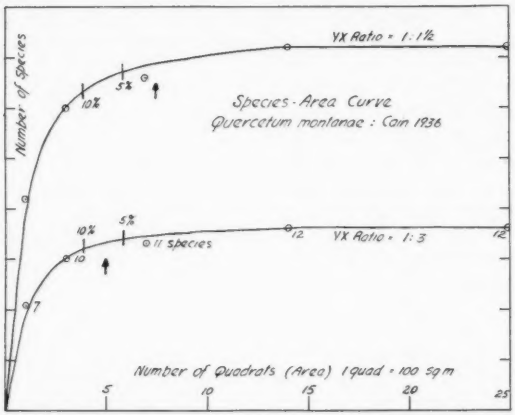


Fig. 3

To state the matter succinctly, one may arbitrarily decide that he will select for the minimal area that point on the curve where an increase of the area by 1/10 gives an increase of 1/10 of the species number. If this should be corroborated by field experience such a procedure should become conventional. In the author's experience such an area apparently does give the characteristic combination of species in most cases. If one wishes greater certainty and time permits, the minimal area may be placed at the point of 5 per cent (1/20) rise for 1/10 area.

We are concerned here, in part at least, with the law of diminishing returns. In Table 1, we find statistics for A1, A2, A3, etc. for certain communities in which A1 represents the first 1/10 of the sample area, A2 the second 1/10 (10-20%), etc. In the *Andropogonetum Hempsteadi*, for example, we find that A1 gives 22 species which are 61 per cent of the total. The further increase of the sample area by 1/10 (A2) adds 6 species and 17 per cent bringing the number sampled to 78 per cent of the total for 20 per cent of the area. A3 adds 3 species and 8 per cent; A4 adds 1 species and 3 per cent, with a total of 89 per cent of the species sampled for 40 per cent of the sample area. The remaining 60 per cent of the area added the 11 per cent of the species remaining unsampled, Figure 4.

The more homogeneous the community the sooner a high percentage of the species is sampled. In terms of the form of the curve it means a steeper initial rise of the curve and a smaller minimal area. This is not a function of the total number of species in the community, although that is undoubtedly an influenct factor. It would seem that a steep initial rise of the curve is an

TABLE 1

Rate of sampling of the total flora of various communities on a basis of one-tenth area units.

One-tenth area units	Species sampled	Per cent of total	Per cent added
Festucetum Halleri (Braun-Blanquet, 1926)			
A1	47	84	84
A2	52	93	9
A3	53	95	2
A1–10	56	100	–
Quercetum montanae: trees only (Cain, 1936)			
A1	9.5	80	80
A2	11.0	92	12
A3	11.6	96	4
A1–10	12.0	100	–
Elynetum (Braun-Blanquet, 1926)			
A1	37.5	75	75
A2	45.0	90	15
A3	49.0	98	8
A1–10	50.0	100	–
Andropogonetum Hempsteadi (Cain, Nelson, McLean, 1937)			
A1	22	61	61
A2	28	78	17
A3	31	86	8
A4	32	89	3
A1–10	36	100	–
Louisiana pinelands, cut-over (Penfound and Watkins, 1937)			
A1	25.0	51	51
A2	33.0	67	16
A3	38.0	78	11
A4	41.0	84	6
A5	42.5	87	3
A1–10	49.0	100	–

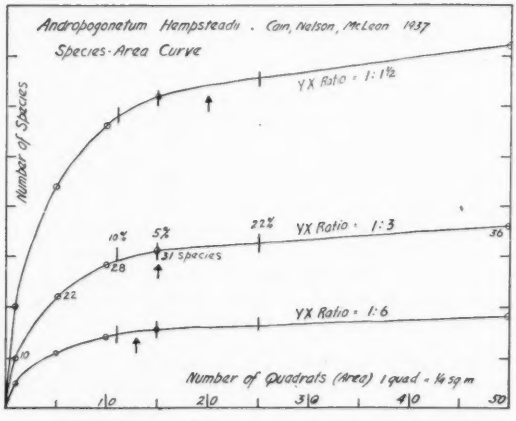


Fig. 4

expression of the fact that there is a relatively large number of species which are of high frequence and density.

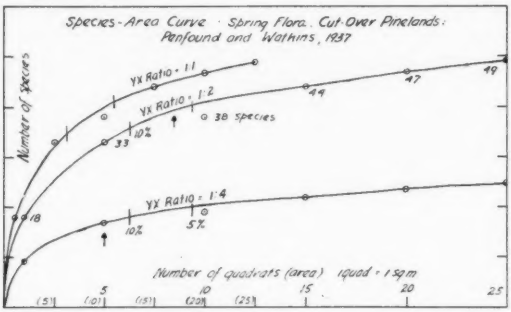


Fig. 5

Summary

1. The so-called species-area curve expresses the relationship between areas of different sizes and the number of species found on those areas. Curves of this sort have been constructed in different ways and used for the following purposes:

a) To determine the minimal area of a community. Whole stands (community individuals) are employed.

b) To determine the minimum quadrat area in the single-plot method, i.e. to determine the least size of quadrat (equivalent to minimal area for the community) to be used in obtaining constancy data.

c) To determine the minimum quadrat area in the multiple-plot method, i.e. to determine the least size of quadrat to be used in obtaining frequency (local frequency) data.

d) To determine the least number of quadrats, of minimal size, which will give an adequate sample of a community: to be used in obtaining either constancy or frequency data.

2. The shape of the species-area curve has been used to indicate the minimal area in the above cases. The point on the curve at which the curve flattens strongly and tends to become asymptote with the x axis (on which area is plotted) is taken to indicate the minimal area. It is shown that the shape of the species-area curve depends on the ratio between the y and x axes which is used in plotting the data. Hence, the shape cannot be used to indicate minimal area, a point overlooked in the literature.

The suggestion is made that a better procedure would be to locate the region of the curve where 1/10 increase in area gives 1/10 increase in species.

A mechanical method of finding this point on the curve is described. Its location on the curve is independent of the ratio between x and y axes which is used.

REFERENCES

BRAUN-BLANQUET, J. 1932—Plant Sociology. Transl. by G. D. Fuller and H. S. Conard. McGraw-Hill, New York.

———UND H. JENNY. 1926—Vegetations-Entwicklung und Bodenbildung in der alpine Stufe der Zentralalpen. Denkschr. d. Schweiz. Naturforsch. Gesellsch. **63**(2):183-344.

CAIN, STANLEY A. 1932—Concerning certain ecological concepts. Ecological Monogr. **2**:475-508.

———1934—Studies on virgin hardwood forest. II. A comparison of quadrat sizes in a quantitative phytosociological study of Nash's Woods, Posey County, Indiana. Amer. Midl. Nat. **15**:529-566.

———1935—Ecological studies of the vegetation of the Great Smoky Mountains. II. The quadrat method applied to the sampling of spruce and fir forest types. Amer. Midl. Nat. **16**:566-584.

———1936—The composition and structure of an oak woods, Cold Spring Harbor, Long Island, with special reference to sampling methods. Amer. Midl. Nat. **17**:725-740.

———, M. NELSON, AND W. MCLEAN. 1937—Andropogonetum Hempsteadi: A Long Island grassland vegetation type. Amer. Midl. Nat. **18**:334-350.

HANSON, H. C. AND L. D. LOVE. 1930—Size of list quadrat for use in determining effects of different systems of grazing upon *Agropyron Smithii* mixed prairie. Jour. Agric. Res. **41**:549-560.

JACCARD, P. 1912—The distribution of the flora in the alpine zone. New Phytol. **11**:37-50.

MOOR, MAX. 1936—Zur Soziologie der Isoëtetalia. Beiträge Geobot. Landesauf. Schweiz **20**:1-148.

PENFOUND, W. T. AND A. G. WATKINS. 1937—Phytosociological studies in the pinelands of southwestern Louisiana. Amer. Midl. Nat. **18**:661-682.

DEPT OF BOTANY,
UNIVERSITY OF TENNESSEE,
KNOXVILLE, TENN.

Further Studies in Southwestern Oaks

Cornelius H. Muller

The descriptions of new species and other categories here recorded are made as one of a series of steps preliminary to an ultimate revision of the oaks of the southwestern United States and northern Mexico. In making such a study care is being taken to consider as significant only those physical geographic features which seem to have resulted in real evolutionary change. Political boundaries especially are disregarded.

The author wishes to make grateful acknowledgement of his indebtedness to the following persons all of whom have aided in making this short work possible: Dr. B. C. Tharp, Mr. L. C. Hinckley, and Mr. Harde LeSueur, University of Texas, who sent the oaks of Mr. Hinckley's Davis Mountains collection and those of Mr. LeSueur's Chihuahuan collection to the author for study; Dr. Carl Epling who allowed the author to spend several days in the herbarium of the University of California at Los Angeles; and Dr. Forrest Shreve who offered the facilities of the herbarium of the Desert Laboratory, Carnegie Institution of Washington, at Tucson, Arizona, for a day's study and generously sent duplicate specimens to the author's oak herbarium.

Subgenus LEUCOBALANUS Engelmann

Series RETICULATAE Trelease

Quercus basaseachicensis sp. nov.

Twigs slender (1-1.5 mm.), distinctly fluted, reddish-brown with tiny inconspicuous lenticels and occasional stellate hairs becoming gray and glabrous the second year. Buds round, glabrous, 1 mm. thick, with the elongate stipules fragmenting but not readily caducous. Leaves deciduous, moderate (2-3.5 x 2.5-5 cm.), stiff and leathery, coarsely dentate with mucronately tipped teeth usually above the middle, margins revolute and crisped, upper surface glabrous and dully shining with the veins and midrib prominent within depressions or grooves, lower surface dull, very sparsely strewn with depauperate simple appressed hairs, the veins and reticulum very prominent; veins about 6 x 2, much branched and distinctly looping, forming angles of 45° with the midrib, the reticulum giving each vein a pinnate appearance; petioles about 3-4 mm. long, glabrous or rarely very sparsely stellate-pubescent on the upper surface. Flowers and fruit?

Ramuli 1-1.5 mm. crassi sulcati rubro-brunnei sparse stellato-pubescentes vel glabri; folia decidua 2-3.5 x 2.5-5 cm. coriacea profunde mucronato-dentata margine revoluto-crispa, supra glabrata, subtus sparsissime pulverulenta; nervis utrinsecus 6, ramosis et anastomosantibus supra impressis subtus prominentibus, angulo 45° divergentibus, trabeculis pinnatis; petioli 3-4 mm. longi glabri vel facie superiore sparse stellato-pubescentes.

MEXICO: Chihuahua, Cascada de Basaseachic, LeSueur *no. 549* (type in the author's herbarium; isotypes in the herbarium of the University of Texas), July 6, 1936.

A study of the fruit of this species will probably result in its removal from the series *Reticulatae* to which it is only distantly related. However, at present there exists no other series to which the species could be referred, and its characters are not sufficiently plain to serve as the basis of a new series.

Series CHIHUAHUENSES Trelease

Quercus santaclarensis sp. nov.

Twigs slender (1-2 mm.), densely gray hairy the first year, noticeably hairy the second, and almost glabrate the third, finally gray with a few inconspicuous lenticels. Buds glabrate, round, 1 mm. thick, the awl-like stipules persistent. Leaves deciduous, small but variable (10 x 20, 12 x 30, 15 x 22, or 22 x 45 mm.), oblong to oval, obtuse to even rounded at the apex but usually with a mucronate tip, the base cordate, entire, flat, the lower surface densely stellate-tomentose, the upper surface noticeably pubescent with appressed stellate hairs, bright green and dully shining above; veins about 7 x 2, branched and plainly looping, prominent even through the tomentum beneath; petioles about 3 mm. long, densely stellate-tomentose. Staminate catkins? Pistillate catkins 1 to 4-flowered (usually 2) on a tomentose peduncle 1 x 5-15 mm. long. Fruit annual, single, in pairs, or grouped or dispersed in threes or fours on a peduncle 10-20 mm. long. Cup deep, scales somewhat thickened and scurfy basally but with long, thin, narrow, appressed, glabrous, light brown apices. Acorn?

Ramuli 1-2 mm. crassi dense stellato-tomentosi annotini pubescentes; gemmae rotundae 1 mm. crassae glabratae, stipulae subulatae persistentes; folia decidua 10 x 20 vel 22 x 45 mm. oblonga vel ovata mucronato-obtusa cordata integra margine plana, supra stellato-pubescentia, subtus dense stellato-tomentosa; nervis utrinsecus 7, ramosis et anastomosantibus infra prominentibus; petioli 3 mm. longi dense stellato-tomentosi; fructus annui 1-4 pedunculo 10-20 mm. longo suffulti; cupula profunda, squamae inferiores crassae incanae, superiores attenuae angustae glabrae appressae.

MEXICO: Chihuahua, Distr. de Chihuahua, Santa Clara Mts., alt. 7100 ft., Shreve *no. 7951* (type in the author's herbarium; isotypes in the herbarium of the Desert Laboratory, Tucson, Arizona), July 23, 1937; "Santa Clara Canyon," LeSueur *no. 434*, October 10, 1935; Rio Verde, LeSueur *no. 538*, July 8, 1936.

"Tree of 10 to 12 m. Young bark dark, old bark lighter. Forming open forest on Santa Clara Mts." (Shreve). This species is very closely related to *Q. chihuahuensis* Trel. In appearance its entire leaves and much reduced tomentum would hardly suggest such a relationship, but in the fruiting characters, insofar as the somewhat immature fruits of *Q. santaclarensis* may be relied upon, the affinity is obvious. Its range is, so far as known, confined to a limited area in which *Q. chihuahuensis* is not found.

Series Opacae Trelease

Quercus bocoynensis sp. nov.

Twigs very slender (1-1.5 mm.), distinctly fluted, brown, glabrous, with a glaucous bloom and becoming gray the second year, light lenticels prominent. Buds round, 1 mm., glabrous, brown, stipules quickly caducous. Leaves deciduous, small (8-15 x 15-30 mm.), ovate to suboblong, subentire to usually shouldered or toothed above, margins somewhat crisped, apex rounded but mucronate-tipped, base strongly cordate, upper surface glabrous but dull green, lower surface yellowish and strewn with exceedingly sparse and depauperate appressed hairs; veins about 7 to 10 x 2, branched and strongly looping, veins and reticulum conspicuous but only slightly raised on both surfaces; petioles 2-3 mm. long, glabrous. Catkins? Fruit annual, single and sessile, or paired or grouped on a peduncle 7-20 mm. long. Cups deep, scales much thickened and canescent basally, the tips flat, rounded, glabrous, and light brown. Acorns?

Ramuli 1-1.5 mm. crassi manifeste sulcati brunnei glabri; gemmae rotundae 1 mm. glabrae; folia decidua 8 x 15 vel 15 x 30 mm. ovata vel suboblonga subintegra vel supra undulata vel dentata crispa mucronato-obtusa manifeste cordata, supra glabra et glauco-viridia, subtus flavida sparsissime pulverulenta; nervis utrinsecus 7-10 ramosis et anastomosantibus; petioli 2-3 mm. longi glabri; fructus annui solitarii vel bini vel diversi pedunculo 7-20 mm. longo suffulti; cupula profunda, squamae inferiores crassae incanae, superiores attenuae glabrae appressae.

Mexico: Chihuahua, Distr. de Bocoyna, 9 mi. N. of San Juanito, Shreve *no. 8022* (type in the author's herbarium; isotypes in the herbarium of the Desert Laboratory, Tucson, Arizona), July 26, 1937; Majalca, LeSueur *no. 206,* August 24, 1935, and *no. 213,* August 20, 1935.

Q. bocoynensis is obviously related to *Q. Pringlei* von Seemen from which it is separated by its leaves broader, cordate, and more characteristically crisped and dentate.

Quercus chuhuichupensis sp. nov.

Twigs slender (1-1.5 mm.), densely gray hairy and hoary for two or three years, ultimately with bark scaling off in flat sheets leaving a smooth surface with few lenticels. Buds light brown, glabrous, ovoid, less than 1 mm. thick, the awl-like stipules persistent for several years. Leaves deciduous, thin, very small (6-10 x 15-30 mm.), acute at the apex with a short mucronate point, the base rounded, entire or rarely slightly undulate or toothed above, the margins crisped, upper surface glossy but inconspicuously strewn with stellate hairs, the lower surface dull and minutely covered with simple appressed hairs; veins about 7 or 8 x 2, slightly conspicuous beneath; petioles about 2 mm. long, densely stellate hairy. Flowers and fruit?

Ramuli 1-1.5 mm. crassi dense griseo-tomentosi; gemmae ovoidae 1 mm. crassae glabrae, stipulae subulatae persistentes; folia decidua attenua 6-10 x 15-30 mm. mucronato-acuta basi rotundata integra vel supra subundulata vel

dentata margine crispa, supra lucida sparsissime stellata, subtus opaca sparsissime pruinosa; nervis utrinsecus 7 vel 8 subtus leviter prominentibus; petioli 2 mm. longi dense stellati.

MEXICO: Chihuahua, "western sierras beyond Chuhuichupa," LeSueur *no. 525* (type in the author's herbarium; isotypes in the herbarium of the University of Texas), August 28, 1936; Distr. de Guerrero, 8 mi. N. of Picachic, alt. 7000 ft., Shreve *no. 8014A*, July 25, 1937, an immature specimen with very hairy juvenile leaves seems to belong here.

This species is only tentatively referred to the series *Opacae*, for although its thin crisped leaves should be enough to exclude it from that series, such a character could hardly serve alone as the basis of a new series. Possibly more complete material will serve to clarify the situation. At present there is no known species in any other series to which *Q. chuhuichupensis* bears the slightest resemblance.

Series LOBATAE x DOUGLASIEAE

Quercus x Eplingi hybr. nov.

(=*Q. Garryana* Douglas x *Q. Douglasii* Hooker & Arnott.)

Twigs slender (2-3 mm.), sparsely stellate-hairy, reddish-brown with prominent lenticels. Leaves deciduous, ovate, 3-5 x 5-8 cm., obtuse above and below or attenuate below, margins rather deeply incised forming 3-4 rounded or mucronately tipped rounded lobes on each side, sinuses usually narrower than lobes, upper surface dark bluish-green, sparsely stellate-hairy, lower surface light green, densely stellate-hairy; petioles 5-8 mm. long, stellate-hairy. Cups resembling those of *Q. Garryana*.

Ramuli 2-3 mm. crassi sparse stellati; folia decidua ovata 3-5 x 5-8 cm. utroque extremo obtusa vel basi attenuata margine profunde incisa lobis utrinsecus 3-4 mucronato-rotundis, supra obscure glauco-viridia sparse stellata, subtus lucida dense stellata; petioli 5-8 mm. longi stellati; cupula ut in *Q. Garryana*.

UNITED STATES: California, Lake Co., "hillside near Clear Lake," Epling & Robinson *without numbers* (type and variations in the herbarium of the University of California at Los Angeles), July 27, 1935.

The fruiting cups of one form of this hybrid (the only ones seen) show the characteristic scales of *Q. Garryana*, a fact which eliminates *Q. lobata* Née from possible parentage. The upper leaf surface and the size, shape, and texture of the leaves rather clearly indicate *Q. Douglasii* as the other parent. Like in most hybrid populations, there have apparently occurred a number of back-crosses which together with interbreeding of the hybrids appear to have produced a number of unstable seggregates. This state of affairs makes the indication of a type specimen a very disagreeable task.[1]

1 Mueller, Cornelius H., Jour. Arn. Arb. **17**:164. 1936. Contains a description of a similar hybrid population in Nuevo Leon, Mexico.

Subgenus ERYTHROBALANUS Oersted

Series VIMINEAE Trelease

Quercus Tharpii sp. nov.

Twigs slender (2 mm.), hardly fluted, from dull reddish-brown becoming quite gray with scarcely discernible lenticels, from sparsely stellate quickly glabrescent. Buds small (scarcely 1 x 2 mm.), acute, glabrous, stipules deciduous. Leaves deciduous ? (the type exhibits a persistent set of leaves on old wood, the new leaves probably resulting from renewed growth in late summer), 1.5-2.5 x 5-9 cm., from remotely stellate-puberulent quickly glabrate and shiny on both surfaces, hard coriaceous, characteristically oblanceolate, the short apices acute, bases cuneate or somewhat rounded, rather deeply 4 or 5-aristate-dentate on each side or entire below the middle; veins about 5 x 2 passing into the teeth and with anastomosing intermediates, somewhat prominent on both surfaces; petioles 5-7 mm. long, glabrate like the blades, flattened above. Flowers and fruit?

Ramuli 2 mm. crassi, annotini glabrescentes grisei; gemmae 1 x 2 mm. acutae glabrae; folia decidua? coriacea mox glabrata et utrinsecus lucida 1.5-2.5 x 5-9 cm. oblanceolata apice acuta basi cuneata vel rotundata utroque profunde 4 vel 5-aristato-dentata vel subtus integra; nervis utrinsecus 5 supra subtusque prominulis, intermediis ramosis et anastomosantibus; petioli 5-7 mm. longi glabrati supra applanati.

UNITED STATES: Texas, Brewster Co., Chisos Mountains, Blue Creek Canyon, Muller *without number* (type in the author's herbarium; isotypes in the herbarium of the University of Texas), August 21, 1933.

Q. Tharpii is a small tree, much branched, and with roughly furrowed, black bark. It is allied to *Q. durazнillo* Trel. and superficially resembles the form *pinetorum* Trel. of that species. *Q. Tharpii* may be distinguished from *Q. durazнillo* by its cuneate leaf bases, its totally glabrous leaves and petioles, and its quickly glabrate twigs exceedingly gray the second year. It is a pleasure to name this species in honor of Dr. B.C. Tharp of the University of Texas under whom the author, as a student, collected in the Chisos Mountains.

Series HYPOLEUCAE Trelease

Quercus livermorensis sp. nov.

Twigs slender (2-2.5 mm.), very inconspicuously fluted, reddish-brown, rather persistently short-hairy the second year with inconspicuous lenticels. Buds 3-4 mm. long, acute, hairy, the stipules deciduous. Leaves evergreen, oblong to oblanceolate, acute, deeply aristately 3 to 4-toothed on each side except about the cuneate or inequilaterally rounded base, margins revolute, blades 3-4.5 x 9-13 cm., from sparsely low-stellate-hairy glabrate and shiny above and persistently velvety beneath with conspicuous domatia; veins about 4 or 5 x 2, passing into the teeth where those are present and having anastomosing intermediates, slightly impressed above and quite prominent beneath; petioles 15-20 mm. long, from low-stellate-hairy glabrate. Staminate catkins

about 25 mm. long, the peduncle hairy, loosely flowered, anthers exserted. Pistillate catkins 1 to 3-flowered on a very short, hairy peduncle. Fruit biennial, solitary or paired, subsessile. Mature fruit not observed.

Ramuli 2-2.5 mm. crassi annotini sparse pubescentes rubro-brunnei; gemmae 3-4 mm. longae acutae sparse tomentosae; folia semperviridia 3-4.5 x 9-13 cm. oblonga vel oblanceolata acuta utrinsecus profunde 3 vel 4-aristato-dentata basin versus cuneata vel rotundata, supra glabrata et lucida, subtus stellato-pubescentia domatiis conspicuis; nervis utrinsecus 4-5, intermediis ramosis et anastomosantibus, supra impressis, subtus prominentibus; petioli 15-20 mm. longi glabrati; amenta ♂ 25 mm. longa tomentosa laxa; amenta ♀ uni- vel triflora pedunculo tomentoso suffulti; fructus biennes solitarii vel bini subsessiles.

UNITED STATES: Texas, Jeff Davis Co., Davis Mountains, Mt. Livermore, Hinckley *no. 935* (type in the author's herbarium; isotypes in the herbarium of the University of Texas), April, 1937.

Q. livermorensis, though superficially quite unlike *Q. hypoleuca* Engelm., is very closely related to that species as it occurs in the eastern parts of its range. This relationship is suggestive of that between the western representatives of *Q. hypoleuca* and certain members of the series *Scytophyllae* of Trelease, notably *Q. epileuca* Trel. and *Q. campanariensis* Trel., in the Sierra Madre Occidental. It is not meant to suggest, however, that these cases of divergence are sufficiently parallel to warrant citation of relationship between *Q. livermorensis* and the *Scytophyllae*. *Q. livermorensis* differs from *Q. hypoleuca* in its larger, long petioled, coarsely dentate, and less tomentose leaves.

Series **Californicae** ser. nov.

(Series AGRIFOLIAE Trelease[2] in part)

Trees or shrubs with leaves deciduous, large, and deeply lobed. Fruit biennial; cup deep with thin, rather large, rounded scales appressed and projecting roughly beyond the edge of the cup.

Arbores vel frutices; folia decidua magna et profunde lobata; fructus biennes; cupulae profundae, squamae attenuae magnae rotundatae appressae.

This series is based on *Q. Kelloggii* Newberry (type) and *Q. Morehus* Kellogg. It differs from the series *Agrifoliae* Trel. both in leaf and fruit characters. *Q. agrifolia* Née, *Q. Pricei* Sudw., *Q. Wislizeni* A. DC., and the following new species are characterized by their small cups with small, loosely appressed scales forming a rough surface at maturity, and by their small evergreen leaves.

Series AGRIFOLIAE Trelease

Quercus Shrevei sp. nov.

Twigs slender (1.5-2 mm., 2.5 mm. on vigorous shoots), dark reddish-brown distinctly fluted with small inconspicuous lenticels. Buds ovoid, subacute, scarcely 1 mm. (mature ?), dull brown, glabrate. Leaves evergreen (persistent more than two years), hard-coriaceous, 10-20 x 25-60 mm., apex

2 Trelease, Wm., Mem. Nat. Acad. Sci. **20**: 205. 1924.

long acute, base rounded or sometimes subcordate, entire to coarsely toothed, the teeth spiny-tipped, edges revolute, concave beneath, light green above, yellowish beneath, glabrous and dully shining save a light pubescence on the upper surface confined to the extreme base on and about the petiole; veins 10-12 x 2, branched and looping, slightly prominent on both surfaces; petioles 1-1.5 x 3-5 mm., glabrous save above near the blade, orange brown in color when dried. Pistillate catkins 1 to 3-flowered, 8-12 mm. long. Fruit biennial, solitary, in pairs, or in threes on penduncles about 3 x 4-8 mm. with prominent lenticels. Cups deep cup-shaped, about 18 mm. wide and 12 mm. high, scales loosely appressed, thin, narrow, ultimately rounded, straw-colored and sparingly downy, the ends projecting roughly beyond the lip of the cup. Acorns about 10 mm. long, 12-14 mm. wide, the base broadest and flat, the apex narrowly rounded or flat, light brown and sparsely hairy above, about half included.

Ramuli 1.5-2 mm. crassi manifeste sulcati obscure rubro-brunnei; folia semperviridia coriacea 10-20 x 25-60 mm. attenuato-acuta, basi rotundata vel subcordata, integra vel profunde dentata margine revoluta, subtus concava, glabra, supra basin versus atque prope petiolum puberula; fructus biennes 1-3 pedunculo 3 x 4-8 mm. suffulti; cupula profunda 18 mm. lata et 12 mm. alta, squamae laxe appressae attenuae angushtae rotundatae; glans 10 mm. longa et 12-14 mm. crassa conica sparse pulverulenta semi-inclusa.

UNITED STATES: California, Monterey Co., ridgetop in Palo Colorado Canyon (about four miles from the ocean), Shreve *no. 104* (type in the herbarium of the Desert Laboratory, Tucson Arizona; isotype in the author's herbarium), July 19, 1918.

A small tree 4-6 m. tall growing scattered in the chaparral of ridgetops above Sequoia-covered canyon sides and floors. This species by its cup characters and small evergreen leaves distinctly shows itself to be closely related to *Q. Wislizeni*. From that species and from *Q. Pricei* it is readily distinguished by its strikingly concave and revolute leaves and its cups with larger scales more roughly projecting and even suggestive of those of *Q. Kelloggii*.

Leaves deciduous, large, thin, flat, deeply lobed ---------- Series *Californicae*.
Leaves evergreen, small, toothed but not lobed ---------- Series *Agrifoliae*.
Leaves flat
Cups deep ---------- *Q. Wislizeni*.
Cups shallow ---------- *Q. Pricei*.
Leaves profoundly concave beneath
Leaves thin ---------- *Q. agrifolia*.
Leaves thick-coriaceous ---------- *Q. Shrevei*.

DEPARTMENT OF BOTANY,
UNIVERSITY OF ILLINOIS,
URBANA, ILLINOIS.

Layering in Black Spruce (Picea mariana (Mill.) BSP.)[1]

Frank C. Gates

Introduction

Layering, as a phenomenon in the reproduction of certain conifers in Europe and Asia, was first called to the attention of botanists by Loudon in 1844. He dealt particularly with Abies and *Picea excelsa* (=*P. abies*), but did mention *Abies nigra* (=*Picea mariana* (Mill.) BSP.).

Quite recently Potzger (1937) described layering in *Thuja occidentalis*, presented detailed references to the literature, and presented a list of 22 conifers in which vegetative reproduction occurred. Nine of these, including *Picea mariana*, have vegetative reproduction by layering.

In North America, Cooper (1911) dealt at length with layering of *Abies balsamea* in the forest of Isle Royale, Michigan. He also stated that black spruce, occurring infrequently in the upland forest did sometimes layer, but that in sphagnum bogs both it and tamarack layered abundantly. These he did not describe.

Layering in the black spruce was described in some detail by Fuller (1913), from the slowly disintegrating granitic areas along the Saguenay river in Quebec.

Prof. G. S. Avery (in personal correspondence) reports the presence of a layering tree of *Picea abies* in a lawn in Groton, Connecticut.

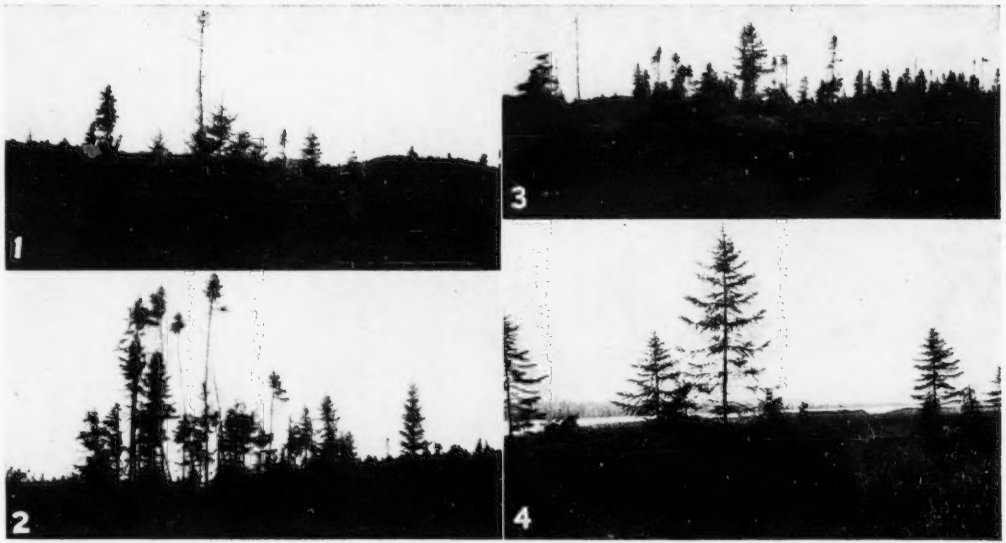
As none of these accounts take up the layering of black spruce in peat bogs, and as the Douglas Lake Region in northern Michigan presents so many excellent examples of layering of black spruce in different peat bogs, it seems reasonable to go into the matter a little in detail.

General Description

The general appearance is that of an older tree surrounded at the base with a fringe of small trees. A few instances have been noted where a tall central tree is surrounded by medium height trees close to it and those in turn by a fringe of smaller trees. (Figs. 1-4.) In deep woods the different groups run together so as not to be readily separated.

The habitat in the Douglas Lake region is exclusively that of the Sphagnum-Chamaedaphne bogs. The best areas are around Mud Lake Bog in Inverness township and at Little Lake 16 in Grant township, both in Cheboygan county.

1 Contribution No. 377, Department of Botany & Plant Pathology, Kansas State College, and a contribution from the Biological Station of the University of Michigan.



Layering in Black Spruce *(Picea mariana)*, Cheboygan Co., Mich. Figs. 1-3 at Mud Lake Bog (foto, August 19, 1933, F. C. Gates). Fig. 4 at Little Lake 16 (foto, August, 1936, G. E. Nichols).

Figs. 1-4: 1. A group with a single central tree. 2. A group with several central trees. 3. A very spread-out group with a large number of layered trees; the central tree had been chopped out. 4. A relatively young group.

Initiation

While black spruce produces seeds in abundance, actual seedlings are seldom discovered in the region. However, the first trees must have started from seeds. At the place of study this was apparently about 70 or 80 years ago. Layering took place when the parent trees were approximately 20-30 years of age. The number of such layered trees in this first installment is seldom above 11, and generally is 3 or 4. Since that time, often the central tree has died, leaving the small group in the center to origintate another circle of layers. (Table 1). It is not possible to tell just how old these central trees might become in this region because the dwarf mistletoe *(Arceuthobium pusillum)* kills them before they reach an age of about 60 years, or they are killed by fire.

Table 1

Transect east from Mud Lake, Cheboygan Co., Michigan, in 1934 showing the number, size and vitality of the trees in the clumps encountered. (Trees over 2 m. high are recorded as tall, and those under 1.5 m. as small. Additional dead trees are in parentheses.)

Tall Trees	Small Trees	Tall Trees	Small Trees
Very open near Mud Lake			
0 (1)	9	1	38
2 (3)	124	2	17 (11)
1	9	5	22 (3)
Chamaedaphne-Sphagnum-Carex area rather open.		2 (2)	29
		3	39 (18)
23 (15)	49		
4 (13)	18	9	23 (15)
2 (4)	17	1 (1)	44 (14)
4 (2)	12	9 (1)	48 (9)
9 (7)	4		
		Chamaedaphne Spruce woods burnt over in 1917, now moderately dense.	
0	1 (seedling)		
2 (3)	22		
4 (3)	4		
		10	14
Dense spruce woods.		0	1 seedling
		0	1 seedling
1	24	1	8
1	7 (3)	2	16
2	21 (2)	20	8
1	17	1	7
2	23	0	1 seedling
		8 (1)	1
3 (1)	9	0 (1)	0
6 (3)	32 (1)		
1 (2)	9 (4)	2	15
1	10 (1)	1	5
1 (2)	24 (2)	5	15
		1	2
2 (1)	13	7 (3)	6
3 (2)	23		
1 (3)	13	3 (1)	13
0 (2)	27 (16)	3 (1)	12
2	9 (9)	7 (2)	37
		27 (1)	14

Development of the Layer

A central tree growing in Sphagnum and Chamaedaphne grows very slowly, both in height and diameter. Height growths during the year are seldom more than 6-12 cm. and the diameter accretions seldom more than .25 to .5 mm. A whorl of one to five or six lateral branches may be produced each year. As the tree increases in size, it increases in weight and sinks slowly into the mass of Sphagnum. The combination of sinking with the growth of Chamaedaphne and Sphagnum brings the Sphagnum up around the lower branches of the spruce. These continually surrounded by wet Sphagnum may in time take root. At that time the plagiotropic growth ceases and the stem grows upright, forming a little tree. It is apparent that in some cases the sinking is more sudden as layered trees from upper (younger) branches may be older than those lower down. (Table 2).

In rocky areas, Fuller found this change of direction of growth took place whether or not the branch became rooted, but in the boggy areas studied roots are always present either before the upright growth begins or coincident with it. Up to the time of this rooting, all of the water and what little minerals the plants get come through the roots of the original tree and the branches which have grown out from it. With the establishment of new roots, however, a new source is provided. In this situation the small tree thus layered retains its connection with the old tree, but occasionally the part next to the old tree dies. No examples that we have discovered were, however, broken off. This part of the stem is down in the acid water surrounding Sphagnum and decay is not expected. The new tree thus rooted proceeds to become independent. Often for quite a while it sends down and back sufficient material to make an annual increment, not only on the upright part, but also along the horizontal part reaching clear back to the original trunk. In time, however, this annual increment becomes thinner and may cease. It is then possible to find small trees, which have been layered branches, showing 5-15 more rings at their bases than are to be found in the original branch where it puts off from the original tree. (Table 2).[2] As the whole mass of central tree and layered surrounding trees gets heavier, it continues to sink deeper into the Sphagnum and the lower part of the central tree ceases to add to its thickness. Such cases present the following data. At the lowest level of the trunk the diameter may be 3 or 4 cm.; at the lowest level of disintegratem Sphagnum the diameter may be about 5 cm. At the layer of living active Sphagnum, the diameter may be as much as 8 or 9 cm. or more and from that level tapers up to the top of the tree.

When fire passes through such an assemblage of trees, the central tree is almost certain to be killed, although not always burned up. It may remain, projecting into the air for several years, but ultimately rots enough to break

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2 A complete group of trees was excavated by an ecology class under the direction of the author and after exhibition turned over to Prof. C. D. LaRue for anatomical investigation. To him the author is indebted for the data upon which table 2 is based.

TABLE 2

Showing some of the relationships between the layered trees and branches from which they arose. Note: Offshoots or uprights marked "D" were dead.

Branch No.	Offshoot			Upright			Distance between rooted branches	Ages and trunk diameters at certain levels
	Age years	Diameter at base	Length	years Age	at base Diameter	Height		
		cm	cm		cm	cm	Total height 238 cm	
1	23	1.25 D	53	30	1.5	68		
	25	0.7					110 cm with no branches rooted	
2	11	0.8	43	25	2.0	66		
	23	0.8	23	22	7.5	55	— branches 21-28	
3	17	0.8	32	28	1.3	61	25 cm	
	17	0.7	37	13	0.6	34		
4	24	1.0 D						
	34	2.3	2.25				— branch 20	
	28	2.1	+3.5				13 cm	
	19	0.5	50			90	— branch 19	38 years.
							9 cm	
5	27	1.6 D	45	30		60		
6	32	0.9	40	32	1.2	66	— branch 18	
7	23	.8 x .9	55	23	0.7	35	8 cm	
8	23	0.6	85	12	0.35	23		
9	27	1.2	65	40 D	0.85		— branch 17	
10	29	0.75	80	18	0.5	24	6 cm	
11	24	0.7 D	78	24	1.3	65		
12	28	0.5 D	86	18	0.5	27	— branch 12-16	
13	28	0.7 D	69	20	0.6	26	4 cm	
14	26	0.7	94	21	0.65	29		
15	22	0.7 D	70	23	0.55	39	— branches 8-11	43 years 6.6 x 5.9 cm.
16	27	0.6 D	75	16	0.55	31	7.5 cm	(44 years most rings)
17	19	0.5	68	10	0.25	10		
18	20	0.8	78	upright buried entirely			— branches 3-7	36 years 4.25 cm
19	24	1.2	22	24	1.3	64	9 cm	
20	20	1.0	20	20	0.6	56 D		
21	21	0.7	70	18	0.4	22	— branch 2	
22	31	0.7	43	28	0.65	52	6.5 cm	
23	22	0.5	31	13	0.35	47		
24	26	1.0	50	22	0.8	48	— branch 1	25 years 3.5 cm
25	21	0.45	58	20	0.45	38	40 cm	
26	32	0.65	68	20	0.5	28		
27	33	0.75	59	23	0.8	45	— root	24 years 2.8 cm
28	33	0.95	50	27	0.9	54		

at about the water level. The layered trees may be burnt completely or, if not burnt up, continue the same type of development, but present irregular patches.

Larix is another conifer which is very common in such areas, seeding freely and germinating freely at intervals. Although more than a hundred have been investigated, not one single example of layering as ordinarily defined, has as yet been discovered in this region. In two cases where trees toppled completely over so that the trunks was brought down into the layer of wet sphagnum, the exposed side branches grew upright and assumed the form of trees. Neither, however, showed the slightest rooting along the trunk.

Summary

A description of layering of black spruce *(Picea mariana)* in Sphagnum-Chamaedaphne bogs in northern Michigan showing the great irregularity in number of layered trees per group and presenting statistics of all members of a single group.

REFERENCES

Cooper, W. S. 1911—Reproduction by layering among conifers. Bot. Gaz. **52**:369-379.

Fuller, G. D. 1913—Reproduction by layering in the Black Spruce. Bot. Gaz. **55**::452-457.

Loudon, J. C. 1844—Arboretum et Fruticetum Britannicum. (p. 2297-8).

Potzger, J. E. 1937—Vegetative Reproduction in conifers. Amer. Midl. Nat. **18**:1001-1004.

Observations on the Distribution of Heuchera arkansana Rydberg *

E. L. Nielsen and O. R. Younge

Heuchera arkansana Rydberg (1905) described from material taken in Benton County, Arkansas, by J. W. Blankinship, has been both meagerly collected and generally not recognized. Only four specimens of this species, all of which were collected prior to 1900, are cited by Rosendahl, Butters, and Lakela (1936) in their recent monograph on the genus *Heuchera*.

In late September, 1937, a colony of this species was found near Wedington Gap in western Washington County of this state. Plants taken from this colony, which were then just beginning to flower, were sent to Dr. Rosendahl for species verification and for establishment in the botanic gardens at the University of Minnesota.

Since then the writers have made rather extensive field studies in an attempt to ascertain the distribution and habits of this heretofore little known species. These observations are briefly set forth in the following paragraphs.

The Wedington sandstone (Branner, 1929) which forms the above mentioned site, is a dense, hard, commonly fine-grained, crystalline rock either of the upper Devonian or lower Mississippian era (Branner, 1929; Croneis, 1930). *Heuchera arkansana* inhabits particularly the cracks and crevices and oftentimes the shaded and rather moist north and east facing escarpments of this formation. It is especially abundant in seepage zones where it is commonly associated with moss species. On south facing and drier exposures it is entirely limited to the shaded cracks and crevices or seepage areas. In this locality plants of this species are very abundant. Counts on north and east facing exposures approximately 15 x 20 feet gave averages of 67 individuals per area.

Blankinship's specimens cited by Rosendahl, Butters, and Lakela were collected from localities in Benton and Washington Counties. The type specimen is annotated "near Springdale, in Benton County." On Martin's Bluff, made up largely of the Sylamore sandstone member of the Devonian (Branner, 1929), or lower Mississippian (Croneis, 1930) series, located in southeast Benton County and extending into Washington County, the species occurs on the moist east and north facing exposures of friable, coarse crystalline sandstone. It was nowhere nearly as abundant here as at Wedington Gap. From a consideration of the date of Blankinship's collections, the mode

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and rate of travel at that time, and the geologic formations upon which plants of this species grow and their nearness to the county line, it appears that this is the type locality for this species.

It also occurs on the soft, coarsely crystalline sandstone escarpments in the White Rock Mountain Game Refuge in north central Franklin County. Here it also occurs quite commonly on the north and east facing exposures of the sandstone members of the Atoka formation of the Pennsylvanian era (Branner, 1929; Croneis, 1930). A single impoverished specimen was collected from a crevice of a southwest facing escarpment.

Fig. 1. Flowering specimen of *Heuchera arkansana* growing in a crevice of the Wedington sandstone, Wedington Gap, Arkansas.

Attempts to find plants of this species growing in similar situations in adjoining portions of Missouri and Oklahoma have to date been unsuccessful. It seems particularly likely that they should occur on the outliers of the Boston Range occurring in the latter mentioned state since they are so abundant at Wedington Gap which is but a few miles east of the Oklahoma boundary. Similarly, attempts to find plants of this species growing in the Ouachita Mountains of Arkansas and Oklahoma have been unsuccessful. Since no specimens have been found growing upon limestone, shale, or on soil, it would appear that the species is entirely restricted to sandstone substrates.

Additional specimens to those already known and listed in the monographic study (Rosendahl et al., 1936) are cited below. The starred specimens are in the Herbarium of the Botany Department of the University of Arkansas, the unstarred in the writers' personal collection.

BENTON COUNTY: Martin's Bluff, Springdale, October, 1922. *J. B. Bucholz**; Martin's Bluff, Springdale, September 1, 1935. *D. M. Moore**; Sylamore sandstone, Martin's Bluff, Springdale, October 10, 1937. *O. R. Younge* and *E. L. Nielson*. No. 5203.

FRANKLIN COUNTY: Dry Atoka sandstone, White Rock Mountain, October 31, 1937. *O. R. Younge* and *E. L. Nielsen*, No. 5274; Atoka sandstone, seepage zone, White Rock Mountain, October 31, 1937. *O. R. Younge* and *E. L. Nielsen*. No. 5275.

NEWTON COUNTY: Sandstone, Mt. Judea, October 11, 1930. *D. M. Moore**.

WASHINGTON COUNTY: Fayetteville, September 1878. *F. Harvey*. No. 134*; Wedington sandstone, shaded and dry, Wedington Gap, September 22, 1937. *Ethellyn H. Nielsen*. No. 5080; Wedington sandstone, above picnic grounds, Wedington Gap, October 3, 1937. *O. R. Younge* and *E. L. Nielsen*, No. 5166.

REFERENCES

BRANNER, GEORGE C. 1929—Geologic map of Arkansas.

CRONEIS, CAREY. 1930—Geology of the Arkansas Paleozoic area with especial reference to oil and gas possibilities. Ark. Geol. Sur. Bull. **3**.

ROSENDAHL, C. O., F. K. BUTTERS, AND O. LAKELA. 1936.—A monograph on the genus *Heuchera*. Univ. Minn. Press. Pp. 35-36.

RYDBERG, PER AXEL. 1905—*Heuchera*, North American Flora **22**:101.

Studies in the Anacardiaceae. III. A Note Concerning the Status of Rhus pulvinata Greene (R. glabra x typhina Koehne)

Fred A. Barkley

At the time the author's recent study[1] was completed there seemed little doubt in his mind that some of the specimens which he had examined, although they fell into two rather well defined groups, were of hybrid origin[2] between *Rhus glabra* L.[3] and *R. typhina* Torner.[4] However, since there was insufficient material available to adequately prove or disprove their hybrid origin, it seemed best to include them provisionally[5] as *Rhus glabra* var. *borealis* Britt.[6] and *R. pulvinata* Greene[7], respectively.

Rhus glabra and *R. typhina* are widely distributed, well known, and long established species. All of the specimens intermediate in character have been obtained in the region of common distribution of the two species (Fig. 1). The most outstanding contrasts between the two species are in the pubescence of the stem and of the fruit. In the case of the former the pubescence of the fruit-coat is predominantly made up of obovoid hairs (Fig. 2a) and the stem, except in the inflorescence, is quite glabrous. In *R. typhina* the pubescence of the fruit-coat is predominantly composed of much elongated hairs (Fig. 2d) and the stem, which is densely villous at first, remains so for about two years and only after several years becomes completely glabrate. In *R. pulvinata* the pubescence of the fruit-coat (Fig. 2c) is similar to that of *R. typhina* but the stem is at first densely puberulent, but after the first year becomes glabrate. In *R. glabra* var. *borealis*, the fruit-coat, which appears to the naked eye similar to that of the species, under a lens is seen to be covered with cigar-shaped trichomes (Fig. 2b), and the stem is at first very sparsely puberulent but very soon becomes glabrate.

In September, 1937, C. C. Deam made a series of collections from a group of sumacs growing in a gravel pit along the road on the south side of Loon Lake in section 20 about three miles northwest of Angola, Steuben County, Indiana. In this collection are typical specimens of *Rhus glabra*

1 Barkley, F. A. A monographic study of *Rhus* and its immediate allies in North and Central America, including the West Indies. *Ann. Mo. Bot. Gard.* **24**:265-498. 1937.
2 Barkley, F. A. *Ibid.*, p. 284.
3 Sp. Pl. **1**: 265. 1753.
4 Cent. Pl. II., p. 14. 1756.
5 Barkley, F. A. *Ibid.*, pp. 340, 330.
6 Manual, p. 601. 1901.
7 In Fedde, Rep. Spec. Nov. **5**: 45. 1908.

(Deam 58426H & 58526E), R. pulvinata (Deam 15428B, 58534A, 58534B & 58534L), and *R. typhina (Deam 58428½),* and specimens that were typical of *R. glabra* var. *borealis (Deam 58424A, 58544L, 58544M, 58544N, 58544O & 58427)* except these specimens appear much more vigorous than specimens previously observed.

While (a) immediate proximity in at least one instance of the presumed hybrids and parent species, (b) the suggestively intermediate morphology of the putative hybrids, and (c) the occurrence of these in the common area of distribution of the parent species, do not prove the hybrid origin of *R. pulvinata* and *R. glabra* var. *borealis,* they make such an hypothesis so probable that the author thought it worth pointing out for the benefit of those botanists in the region where these plants occur who might be particularly interested in them. In order to test this assumption, seeds of the four types from the Deam collections are being planted for genetical study of the problem.

Considering the common occurrence (Fig. 1) of the *R. pulvinata* type, it may be desirable to continue to designate it by a name, in which case the present accepted name, *(x) R. pulvinata* would seem preferable.

Department of Botany,
Montana State University,
Missoula, Montana.

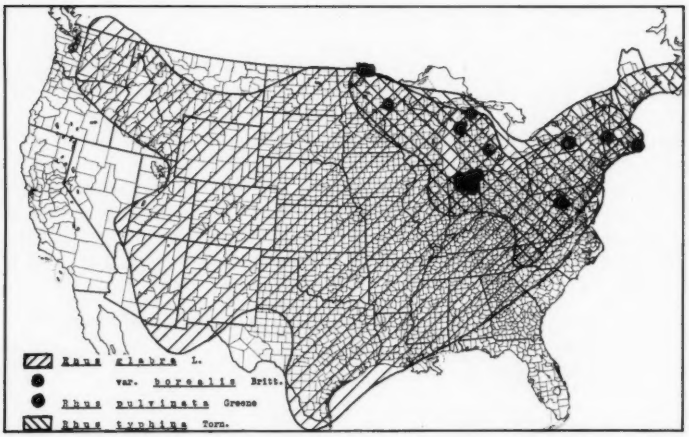

Fig. 1. The distribution of *Rhus glabra* var. *borealis* and *Rhus pulvinata* Greene in relation to the general area of distribution of *Rhus glabra* L. and *Rhus typhina* Torn.

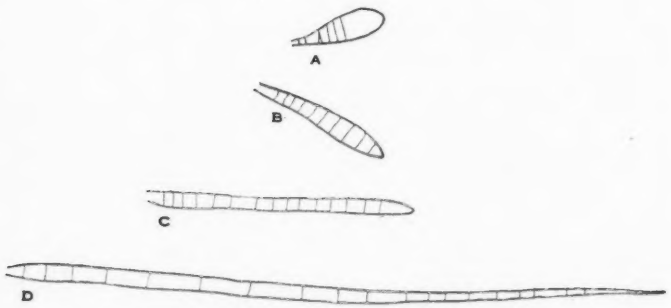

Fig. 2. Typical trichomes from the epicarp of *Rhus glabra* L. (A), *Rhus glabra* var. *borealis* Britt. (B), *Rhus pulvinata* Greene (C), and *Rhus typhina* Torn. (D). x55.

Some Blood Parasites from Nebraska Birds—II*

G. Robert Coatney and Evaline West

This study deals with the protozoan genera *Haemoproteus, Leucocytozoon, Plasmodium,* and *Trypanosoma.* The material was collected for the most part in the vicinity of Peru, Nebraska, during the spring and summer of 1937. Altogether eighty-four different birds were examined, comprising nineteen families. Fifteen species, out of the thiry-five examined, were found to be infected with one or more genera of blood parasites.

The vernacular and sicentific names of the hosts, and the methods used in collecting and studying the material are the same as outlined in the first paper of this series by Coatney and Roudabush (1937).

The authors are indebted to Dr. George E. Hudson of the University of Nebraska for smears from certain birds taken in the vicinity of Lincoln, Nebraska.

Haemoproteus Kruse, 1890

Haemoproteus archilochus sp. nov.

Pl. 1, Figs. 1-2

A Ruby-throated Hummingbird *(Archilochus colubris)* was captured in one of the college buildings and upon examination was found to harbor a very heavy halteridium infection. A search of the literature fails to reveal a single record of Haemoproteus parasites from any member of the family Trochilidae.

The female parasites measured from 15.84μ to 25.08μ in total length and from 2.31μ to 3.96μ in width with a mean of 20.84μ by 3.22μ. Over one-half of the adult parasites completely enclosed the host cell nucleus. If not surrounded by the parasite, the host cell nucleus was decidedly displaced laterally. Elliptical to rod-shaped granules were scattered throughout the cytoplasm. They varied in size from dust-like particles to bodies 1.4μ in length. In number these granules ranged from 6 to 20 with an average of 15.5. The cytoplasm stained a pale blue; the vacuoles were few and indistinct. The parasite membrane was in close contact with the nucleus and the periphery of the host cell. The pale pink nucleus varied in both shape and position within the host cell. Characteristically, it was oval and lay opposite the host cell nucleus near the periphery, with its long axis parallel to the long axis of the parasite. The nucleus was sometimes found near one end where it took up a diagonal position within the cell. A few crescent shaped nuclei were observed. In

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length the nucleus ranged from 2.64μ to 5.94μ and in width from 1.32μ to 3.30μ. The mean size was 4.37μ by 2.16μ.

The male parasites measured from 14.52μ to 22.77μ in total length and from 3.30μ to 4.62μ in width with a mean size of 18.35μ by 3.79μ. The tendency to either surround the host cell nucleus or to displace it laterally was about the same as described above for the female parasites. The cytoplasm had a decidedly clear, hyaline appearance. The elliptical to rod-shaped granules ranged in number from 8 to 18 with a mean of 11.4. The nuclear boundary could not be distinguished with certainty in any of these specimens. The adult parasites of both sexes brought about a slight hypertrophy of the host cell in both length and width.

Haemoproteus quiscalus sp. nov.

Pl. 1, Figs. 3-4

Haemoproteus parasites have been reported from several members of the family Icteridae and from various parts of the world (see Coatney, 1936). In the main, the species encountered have not been determined, although Novy and MacNeal (1905) provisionally reported *H. rouxi* from the Baltimore Oriole and Plimmer (1913) reported *H. danilewskii* from *Agelaeus icterocephalus*. The parasites reported here are from the Bronzed Grackle *(Quiscalus quiscula aenus)*.

Halteridia were found in the blood of one adult and one immature bronzed grackle. The parasites were rare in the blood of both birds and no young forms were seen. The female parasites measured from 12.87μ to 19.14μ in total length by 1.65μ to 2.97μ in width with a mean of 15.49μ by 2.24μ. The ends of the parasites were rounded or pointed and they had a tendency to curve around the ends of the host cell nucleus. The parasite membrane was usually in contact with the host cell membrane and its nucleus, but in some cases it was free from both at the ends. The cytoplasm stained a dark blue and contained numerous small, round vacuoles. A large, clear area was present at the center of the parasite in about 6 out of 10 parasites (Fig. 4). Large, dark brown, elliptical to rod-shaped granules were found scattered throughout the cytoplasm. These granules ranged in number from 5 to 15 with an average number of 8.5. The dark pink nucleus was semicircular or elliptical and was situated at, or near, one end, in contact with the periphery of the parasite. It measured from 1.65μ to 3.30μ in length by 1.32μ to 2.64μ in width with a mean size of 2.70μ by 1.75μ. The parasite caused the host cell nucleus to be laterally displaced, but no host cell hypertrophy was evident.

The adult microgametocytes measured from 11.88μ to 17.16μ in total length by 1.65μ to 2.64μ in width with a mean of 14.37μ by 2.19μ. The ends of the parasites were usually rounded and they had a tendency to surround the host cell nucleus. No vacuoles were observed in the pink staining cytoplasm. Large, elliptical to rod-shaped granules were localized at the ends of the parasite. The granules ranged from 6 to 12 in number with an average of 9.3. The pink nucleus was irregular in outline. This body was as wide as the parasite itself and in length measured from 5.94μ to 7.26μ with a mean of

6.81μ. More than one-half of the male parasites showed a karyosome which measured up to 1.4μ in diameter and was located at the extreme end of the nucleus or just outside of it. This body was spherical or elliptical and stained a bright red. The parasite membrane was in close contact with the periphery of the host cell and its nucleus. The host cell nucleus was displaced laterally and there was no host cell hypertrophy.

H. quiscalus differs from other described species of the *H. columbae*-type in that the microgametocytes possessed a large, distinct karyosome and the macrogametocytes showed a large, irregular vacuole near the center.

Haemoproteus danilewskii Kruse

Early in June, 1937 a young Eastern Crow *(Corvus branchyrhynchos)* was taken when about ready to leave the nest and kept captive in the laboratory for thirteen days. When first seen the bird harbored an heavy infection of *H. danilewskii* which continued practically unabated during the period of observation. All stages in the growth of the parasite were present and multiple infections of the host cells were common. This bird also harbored a heavy Leucocytozoon infection and, while under observation, one trypanosome was found.

Kruse (1890) named this species from the Hooded Crow *(Corvus cornix)* and set forth the characteristics that were evident with methylene blue stain. With ample material and better methods of staining it is now possible to make certain additions to the original description.

The mature female parasites measured 11.22μ to 23.10μ in length by 2.31μ to 4.62μ in width with a mean size of 17.41μ by 3.22μ. The nucleus was spherical to oval and stained a dark pink. It measured 1.98μ to 4.95μ in total length by 1.32μ to 2.97μ in width with a mean size of 2.99μ by 2.26μ. The elliptical to rod-shaped granules ranged in number from 10 to 26 with an average number of 15.

The adult microgametocytes were 12.21μ to 21.12μ in length by 2.64μ to 5.28μ in width. The mean was 16.17μ by 3.35μ. The pale pink nucleus was decidedly diffuse. It completely filled the parasite in width and had a length of 4.62μ to 8.91μ with a mean of 6.51μ. The granules ranged from 9 to 24 in number with an average of 17. In both the micro- and macrogametocytes a red-staining karyosome was present just outside or adjacent to the periphery of the nucleus.

As pointed out by Kruse, the full grown parasites surrounded the nucleus and completely filled the host cell. This is contrary to a statement by Coatney and Roudabush (1937) who, when that paper was written, had not seen the parasite of *H. danilewskii*, and, as a consequence, did not fully appreciate Kruse's description. There are now three species of this genus that completely fill the host cell. *H. velans* is the largest of this group with large vacuoles at the poles of the parasite and many granules. In the microgametocytes these granules even invade the region of the nucleus. *H. danilewskii* has many small vacuoles in the cytoplasm and an average of 16 granules. These para-

sites also showed "radiating lines" which is decidedly characteristic of this species. *H. archilochus* is practically without vacuoles and the cytoplasm of the males is decidedly hyaline. In cases where the adult parasite does not surround the host cell nucleus, it is strongly displaced laterally and, as a result, the host cell becomes somewhat spheroidal.

Haemoproteus sp.
Pl. 1, Figs. 5-6

The Baltimore Oriole *(Icterus galbula)*, the host of the parasites reported here, is a member of the family Icteridae and a brief history of Haemoproteus parasites from members of this family is given under *H. quiscalus*.

The mature female gametocytes measured from 10.89μ to 14.52μ in total length and from 2.31μ to 3.63μ in width with a mean size of 12.97μ by 2.97μ. The ends of the parasite were rounded. The cytoplasm had indistinct vacuoles and stained a pale blue. The nucleus stained pink. This irregularly shaped body was quite distinct and, in all specimens, was found toward one end of the parasite. The nucleus measured from 1.98μ to 3.30μ in length by 1.98μ to 3.30μ in width with a mean of 2.85μ by 2.64μ. The reddish granules were scattered throughout the cytoplasm. In those specimens in which the granules could be counted the number ranged from 16 to 24 with an average of 21. The parasites caused some lateral displacement of the host cell nucleus and the parasite membrane was in very close contact with the host cell membrane and its nucleus. There was no host cell hypertrophy.

The adult microgametocytes measured from 9.24μ to 13.86μ in total length by 2.31μ to 4.62μ in width. The mean size was 11.81μ by 3.09μ. The cytoplasm of the parasites stained a pale pink and the vacuoles were indistinct. The granules numbered from 9 to 12 with an average of 10.2. The nucleus measured from 5.28μ to 9.24μ in length with a mean size of 7.00μ. This body stained a light pink and was markedly diffuse. The ends of the parasites were rounded and, as with the females, the parasite membrane made close contact with the host cell nucleus and the host cell membrane. There was some lateral displacement of the host cell nucleus, but no host cell hypertrophy. Both male and female parasites, in all stages of growth, were occasionally found in leucocytes.

Haemoproteus sp.
Pl. 1, Figs. 7-8

One Blue Jay *(Cyanocitta cristata)*, out or seven examined, showed a light halteridium infection. The perfunctory examination of the slides showed parasites similar in appearance to the elongate gametocytes of some of the plasmodia. Consequently, a clean canary was given an intravenous inoculation of blood from this host but with negative results. Further study of the original slides showed the infection to be that of an Haemoproteus.

Novy and MacNeal (1905) seem to have been the first investigators to record Haemoproteus parasites from the blue jay. They found *H. majoris*,

H. danilewskii, and *H. rouxi*. Huff (1937) (see Coatney and Roudabush, 1937) has found what is probably *H. velans* in this bird also.

The female parasites measured from 11.22μ to 14.52μ in length by 1.65μ to 2.97μ in width with a mean size of 13.92μ by 2.22μ. The ends of the parasites were irregular in outline (Fig. 8). There was close contact between the parasite membrane and the host cell nucleus. The periphery of the parasite extended to the host cell membrane at the center but was not always in contact with it at the ends. The ends of these parasites stained a dark pink and only a small area near the middle stained blue. No vacuoles were observed. In the majority of specimens the nucleus could not be distinguished. However, a few parasites showed a semicircular nucleus located at the center and in contact with the periphery (Fig. 8). This body stained the same color and seemed to be of the same consistency as the cytoplasm at the ends of the parasite. In many of the specimens the black granules were fused into a solid mass. Where a count could be made, they ranged in number from 3 to 10 with an average of 7.3.

The male parasites varied from 12.54μ to 17.16μ in length and from 1.32μ to 2.64μ in width. Their mean size was 14.32μ by 1.91μ. The shape of the parasites, their tendency to contact the host cell nucleus and the periphery of the host cell were much the same as decribed for the females. The black granules were large and irregular. They were so closely fused that an accurate count could not be made. The cytoplasm stained a pale pink. In some of the parasites a nucleus could be observed, but the outline was so indefinite as not to allow for accurate measurements. Both male and female parasites caused a very slight lateral displacement of the host cell nucleus. Hypertrophy of the host cell was not evident.

Haemoproteus sp.

Haemoproteus parasites were found in a Lincoln's Sparrow *(Melospiza l. lincolni)*, but were too few to allow for detailed study.

Leucocytozoon (Leucocytozaire) Danilewsky, 1890

Leucocytozoon coccyzus sp. nov.

Pl. 1, Figs. 9-10

The blood of one Yellow-billed Cuckoo *(Coccyzus a. americanus)*, out of three examined, carried a heavy infection of the Leucocytozoon of the round type plus trypanosomes and microfilaria. A search of the literature failed to reveal any record of a Leucocytozoon from a member of the family Cuculidae, or the order Cuculiformes, to which the cuckoos belong.

In a majority of the specimens the host cell nucleus was pushed to the outside and formed a cap over the parasite. In some, however, the host cell nucleus partially surrounded the parasites. The host cells containing female parasites measured from 13.20μ to 16.50μ in length and 11.88μ to 12.54μ in width with a mean of 14.98μ by 12.34μ. The host cells harboring male parasites measured from 10.56μ to 15.84μ in length by 9.90μ to 12.54μ in width

with a mean of 12.98μ by 11.66μ. Both the micro- and macrogametocytes contained relatively large granules which stained a dull red. The cytoplasm of the parasites was interspersed with numerous small, round vacuoles. A karyosome was not observed.

The female gametocytes stained dark blue and measured from 11.88μ to 13.86μ in length by 9.90μ to 11.88μ in width. The mean size was 12.69μ by 10.56μ. The nucleus was rather inconspicuous, and, in some specimens, so indistinct that its boundaries were difficult to determine. This body was oval in shape and stained a reddish pink. The nucleus measured 2.64μ to 4.62μ in length by 1.32μ to 2.64μ in width, with a mean size of 3.84μ by 1.98μ.

The male parasite measured from 10.56μ to 15.18μ in length by 8.58μ to 11.22μ in width with a mean size of 12.32μ by 9.46μ. The cytoplasm stained a pale blue and inclosed a large, pink nucleus which measured 6.60μ to 8.58μ in length and 3.96μ to 5.61μ in width. The mean size was 7.26μ by 4.54μ

Leucocytozoon sakharoffi Sambon
Pl. 1, Figs. 11-12

Leucocytozoa have been frequently reported from members of the subfamily Corvinae. The first record seems to be that of Sakharoff (1893), who reported these parasites from the rook and the raven. In 1908 Sambon proposed the name *L. sakharoffi* for the parasites of the raven *(Corvus corax)* and gave a brief description, but no figures. Leger (1913), according to M. and A. Leger (1914), designated the parasites found by him in the blood of *Corvus corone* as *L. zuccarelli.* M. Leger (1917) reported a Leucocytozoon from *Corvus corax,* taken in France, and held that these parasites were different from *L. sakharoffi* and more of the *L. mesneli*-type.

The Leucocytozoa under discussion here were found in an immature Eastern Crow *(Corvus brachyrhynchos)* and are considered to be *L. sakharoffi* Sambon. (There seems to be no essential morphological differences between *H. sakharoffi* and *H. zuccarelli,* and the former name has priority over *H. zuccarelli.)* In this account, it is proposed to amplify Sambon's description and include figures of the parasites.

The host cells containing female parasites ranged in length from 15.84μ to 17.82μ and in width from 12.54μ to 15.18μ. The mean size was 17.20μ by 14.11μ. The cells containing microgametocytes measured from 11.88μ to 17.16μ in length by 11.22μ to 16.17μ in width with a mean of 14.79μ by 12.49μ

The female gametocytes measured 11.88μ to 14.52μ in length and 9.90μ to 12.54μ in width. The average was 13.81μ by 11.32μ. Their nuclei ranged in length from 3.30μ to 5.28μ and in width from 1.98μ to 3.96μ. The mean size of the nucleus was 4.61μ by 2.84μ. A karyosome, which lay just outside the nucleus and in contact with it, was present. This body measured from 0.66μ to 1.32μ in length by 0.33μ to 0.66μ in width with an average size of 0.80μ by 0.57μ.

The macrogametocytes ranged from 10.56μ to 14.52μ in length by 7.92μ

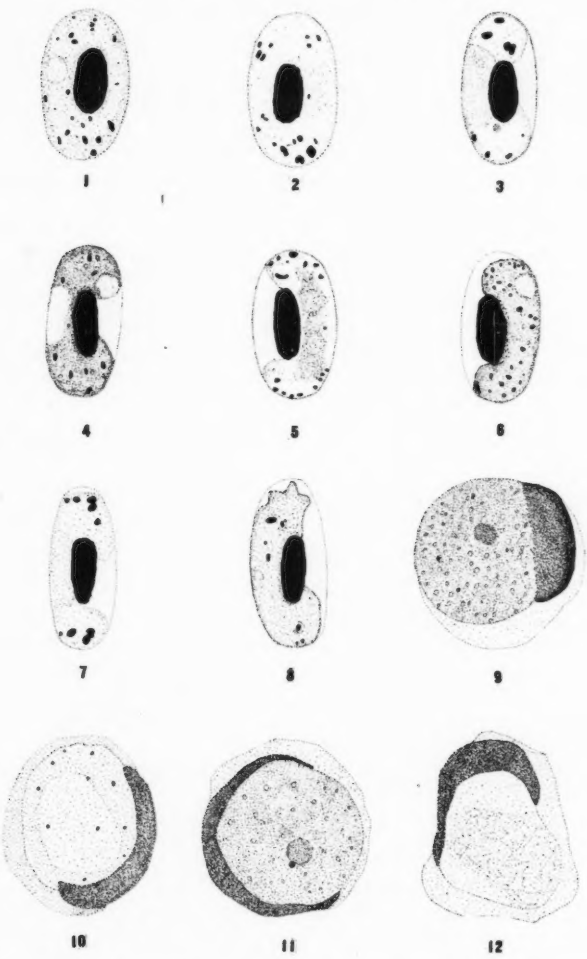

Plate 1. (Figs. 1-10 are x1942; Figs. 11-12 are x1750.) Figs. (1-2) *Haemoproteus archilochus* from the Ruby-throated Humming bird. Showing a macro- and microgametocyte entirely enclosing the host cell nucleus. (3-4) *Haemoproteus quiscalus* from the Bronzed Grackle. A micro- and macrogametocyte. (5-6) *Haemoproteus* sp. from the Baltimore Oriole. A micro- and macrogametocyte. (7-8) *Haemoproteus* sp. from the Blue Jay. A micro- and macrogametocyte. (9-10) *Leucocytozoon coccyzus* from the Yellow-billed Cuckoo. A macro- and microgametocyte. (11-12) *Leucocytozoon sakharoffi* from the Eastern Crow. A macro- and microgametocyte.

to 11.55μ in width with a mean of 12.03μ by 9.57μ. As pointed out by Sambon (1908), the cytoplasm was of a greyish color. The nucleus was extremely large and had granular to slightly reticular chromatin, which stained a rather bright pink. The nucleus measured from 5.28μ to 10.56μ in length by 3.96μ to 7.92μ in width, and had a mean size of 8.73μ by 5.97μ.

Plasmodium Marchiafava and Celli, 1885

The blood of one immature Eastern Crow *(Corvus b. brachyrhynchos)*, out of the three examined, showed the presence of a plasmodium. The parasites were not numerous, but enough adult gametocytes were found to determine the species as *P. relictum*. A search of the literature reveals two other records, both from Europe, of a plasmodium from members of the subfamily Corvinae. Plimmer (1927) reported a plasmodium from the Raven, and Nikitine and Artemenko (1927) reported a plasmodium from the Rook.

Thirteen younk Robins *(Turdus m. migratorius)* were examined for plasmodia and one was found to harbor an infection with what is considered to be *P .relictum*. This was a beginning infection and only two adult gametocytes could be found. However, these were definitely of the relictum-type. *P. relictum* was also found in one English Sparrow *(Passer domesticus)* out of five examined.

Plasmodium nucleophilum was found in a Purple Martin *(Progne subius)*. We are indebted to Dr. R. D. Manwell, who originally described this species, for slides for comparison with our material.

Experimental

Coatney and Roudabush (1937) reported a mixed infection of plasmodium in the Magpie *(Pica pica hudsonia)*. The canary was found to be susceptible to the strain with round gametocytes *(P. cathemerium)*, but refractory to the other with elongate gametocytes. The following experiments were carried out to test the susceptibility of other birds to these malarias.

Experiment 1-A. An immature Bronzed Grackle *(Quiscalus quiscula aeneus)* was given 0.35cc. of magpie blood by intravenous injection. The grackle had been under observation for 15 days and smears had been made daily with no evidence of malarial infection. This bird did not become infected with either strain as determined by smears made daily for 16 days following the injection.

It is entirely possible that this bird carried a latent infection when placed in captivity, which might account for its being refractory, in as much as Manwell and Herman (1935) found a purple grackle naturally infected with *P. cathemerium*.

Experiment 2-A. An immature Blue Jay *(Cyanocitta cristata)* was kept under observation for 13 days prior to injection. Examination of blood smears during this period showed it to be negative for all blood protozoa. An intravenous injection was made with blood from a canary having a very heavy infection of *P. cathemerium*. Parasites appeared in the blood after a prepatent period of 5 days. For the next 6 days a steady increase in the parasite num-

TABLE 1. *Trypanosoma avium*. With Myonemes.
Measurements of Specimens from Various Hosts.

		Long-tailed Chickadee (1)	Mourning Dove	Brown Thrasher (6)	Blue Jay (1)	Crow (1)	Yellow-billed Cuckoo (2)	Totals for all Specimens
Posterior end to middle of parabasal body	Range	15.38μ	11.88–23.10μ	15.18–17.82μ	15.18μ	16.50μ	10.89–11.88μ	10.89–23.10μ
	Aver.		16.43μ	16.23μ			11.39μ	15.78μ
Middle of parabasal body to middle of nucleus	Range	6.41μ	6.60–11.22μ	7.92–9.90μ	7.26μ	8.91μ	7.92–10.23μ	6.60–11.22μ
	Aver.		8.30μ	9.08μ			9.08μ	8.48μ
Middle of nucleus to anterior end of body	Range	19.23μ	15.84–23.76μ	17.82–26.73μ	19.14μ	17.49μ	21.12–21.78μ	15.84–26.73μ
	Aver.		19.57μ	22.99μ			21.45μ	20.59μ
Length of flagellum	Range	5.13μ	6.60–11.22μ	5.94–10.89μ	3.30μ	5.61μ	5.61–6.60μ	3.30–11.22μ
	Aver.		9.47μ	8.25μ			6.11μ	8.12μ
Length (sum of the separate measurements)	Aver.	46.15μ	53.77μ	56.55μ	44.88μ	48.51μ	48.03μ	52.97μ
Width	Range	4.80μ	4.95–7.26μ	4.62–7.59μ	5.94μ	5.28μ	4.95–5.28μ	4.62–7.26μ
	Aver.		5.81μ	5.83μ			5.12μ	5.68μ
Length of nucleus	Range	4.16μ	3.96–6.60μ	3.96–7.26μ	5.94μ	5.28μ	4.62–5.28μ	3.96–7.59μ
	Aver.		5.41μ	5.39μ			4.95μ	5.32μ
Width of nucleus	Range	3.85μ	2.97–4.62μ	3.63–4.62μ	4.62μ	3.96μ	3.30–4.62μ	2.97–4.62μ
	Aver.		3.81μ	4.18μ			3.96μ	3.98μ

Figure in bracket gives the number of specimens measured, if less than 10.

TABLE 2 *Trypanosoma avium*. Without Myonemes.
Measurements of Specimens from Various Hosts

		Long-tailed Chickadee	Orchard Oriole	Bronze Grackle (3)	Mourning Dove	Yellow Warbler (9)	Totals for all Specimens
Posterior end to middle of parabasal body	Range	1.60–2.56μ	2.88–5.77μ	0.96–1.92μ	0.33–3.63μ	0.66–5.94μ	0.33–5.94μ
	Aver.	2.29μ	3.85μ	1.25μ	1.68μ	3.96μ	2.50μ
Middle of parabasal body to middle of nucleus	Range	4.81–8.02μ	5.77–7.69μ	6.73–7.69μ	7.26–10.89μ	5.94–8.91μ	4.81–10.89μ
	Aver.	6.40μ	6.61μ	7.16μ	8.88μ	7.52μ	7.67μ
Middle of nucleus to anterior end of body	Range	5.16–10.57μ	7.69–11.54μ	5.77–12.82μ	5.28–11.22μ	7.92–9.90μ	5.16–12.82μ
	Aver.	7.94μ	10.06μ	9.65μ	7.91μ	9.25μ	8.55μ
Length of flagellum	Range	6.09–8.65μ	7.05–9.62μ	6.41–10.26μ	4.62–8.91μ	5.61μ	4.62–10.26μ
	Aver.	7.16μ	7.42μ	8.01μ	7.00μ		7.15μ
Length (sum of the separate measurements)	Aver.	23.79μ	27.94μ	26.07μ	25.47μ	26.34μ	25.87μ
Width	Range	4.17–7.37μ	4.80–7.37μ	5.77–8.65μ	4.62–8.25μ	3.63–6.60μ	3.63–8.65μ
	Aver.	5.72μ	5.83μ	7.37μ	6.40μ	5.50μ	6.07μ
Length of nucleus	Range	3.21–7.37μ	4.49–7.37μ	6.41–8.01μ	3.30–7.92μ	3.63–6.27μ	3.21–8.01μ
	Aver.	5.54μ	5.72μ	7.05μ	5.54μ	5.06μ	5.57μ
Width of nucleus	Range	1.60–3.21μ	2.24–3.53μ	3.21–4.81μ	1.98–4.29μ	2.31–3.96μ	1.60–4.81μ
	Aver.	2.24μ	2.93μ	3.74μ	3.14μ	3.04μ	2.93μ

Figure in bracket gives the number of specimens measured, if less than 10.

ber was shown, and a maximum was reached on the 7th day when the blood contained about 20 parasites per microscopic field. There was a decided drop in the number of parasites on the 8th day, and all slides made after the 9th day were negative.

A clean canary was subinoculated from this young blue jay, and a typical *P. cathemerium* infection became established after a prepatent period of 4 days.

Experiment 2-B. Frequent smears were made from an adult blue jay during a 10 day observation period and during this time, there was no evidence of malarial infection. However, this bird did harbor light infections with *Trypanosoma avium, Leucocytozoon laverani,* and *Haemoproteus* sp. This bird was then inoculated from the immature jay, of experiment 2-A, 3 days after parasites first appeared in its blood. A few parasites were found in the blood of the adult bird after an incubation period of 7 days. During the next 3 days the parasite number did not greatly increase. On the 5th day the infection was well established and the bird was released.

P. cathemerium has not been reported as occurring as a natural infection in the blue jay, although the results given above show this host to be susceptible to the magpie-strain of this species. A natural infection will undoubtedly be found when a larger number of jays are examined.

Trypanosoma Gruby, 1843

Trypanosoma avium Danilewsky

Trypanosomes reported in the present work were found in one Long-tailed Chickadee *(Penthestes atricapillus septentrionalis),* one Eastern Crow *(Corvus brachyrhynchos),* one Yellow-billed Cuckoo *(Coccyzus a. americanus),* one Bronzed Grackle, *(Quiscalus quiscula aenus),* one Blue Jay *(Cyanocitta cristata),* one Baltimore Oriole *(Icterus galbula),* one Orchard Oriole *(Icterus spurius),* one Brown Thrasher *(Toxostoma rufum),* one Yellow Warbler *(Dendroica aestiva),* and four Mourning Doves *(Zenaidura macroura carolinensis).* All the trypanosomes are considered to be *T. avium.*

Coatney and Roudabush (1937) also reported trypanosomes from the blue jay, yellow-billed cuckoo and the Baltimore oriole. However, the parasites from the blue jay were non-myonemed, and only one myonemed specimen was found in the blood from the yellow-billed cuckoo. As a result of the present work, a myonemed form was found in the blue jay and two additional specimens, of the same form, were found in the yellow-billed cuckoo. The measurements of the specimens from the different birds are given in Table 1 and 2. (The measurements of the specimens from the Baltimore oriole and the non-myonemed forms from the yellow-billed cuckoo agree with the data of Coatney and Roudabush and are, therefore, not included in the above tables.)

In the paper mentioned above, Coatney and Roudabush presented evidence on both sides of the question as to whether the large, myonemed forms change to become the smaller non-myonemed forms or *vice versa.* No definite conclusion was advanced, although it was pointed out that only non-myonemed forms were found in any stage of division. In three birds, two nestling mourn-

ing doves and a yellow-billed cuckoo, rather heavy trypanosome infections were encountered, and it was hoped that a study of these infections might throw additional light on this controversial point. The cuckoo harbored both forms of *T. avium* with the non-myonemed forms being particularly numerous, yet none, of either form, were found in any stage of division. One dove died within a few hours, due to an injury. Careful study of numerous slides showed no division forms. The other dove was kept captive for a period of two weeks. Parasites were present during the first eight days, although the total number gradually decreased until they completely disappeared. No morphological changes were noted, and no parasites were found in division.

The following birds were negative for blood-inhabiting organisms (PERU REGION): (2) Blue-winged Teal *(Querquidula discors);* (1) Domestic Duck (*Anas* sp.); (2) Domestic Chicken *(Gallus gallus);* (1) Domestic Turkey *(Meleagris gallopava domestica);* (1) Yellow-billed Cuckoo *(Coccyzus a. americanus);* (3) (1 im., 2 ad.) Chimney Swift *(Chaetura pelagica);* (2) Red-headed Woodpecker *(Melanerpes erythrocephalus);* (3) Barn Swallow *(Hirundo erythrogaster);* (7 im.) Purple Martin *(Progne s. subius);* (8) (7 im., 1 ad.) Northern Blue Jay *(Cyanocitta c. cristata);* (1 im.) Eastern Crow *(Corvus b. brachyrhynchos);* (1) Long-tailed Chickadee *(Penthestes atricapillus septentrionalis);* (1) Catbird *(Dumatella carolinensis);* (1) Brown Thrasher *(Toxostoma rufum);* (12 im.) Eastern Robin *(Turdus m. migratorius);* (1) Eastern Golden-crowned Kinglet *(Regulus satrapa satrapa);* (4) English Sparrow *(Passer d. domesticus);* (1) Baltimore Oriole *(Icterus galbula);* (2) Orchard Oriole *(Icterus spurius).*

LINCOLN REGION): (1) Shoveller Duck *(Spatula clypeata);* (1) Greater Prairie Chicken *(Tympanuchus cupido americanus);* (1) Tufted Titmouse *(Baeolophus bicolor);* (1) Eastern Warbling Vireo *(Vireo g. gilvus);* (1) Bell's Vireo *(Vireo b. belli);* (1) Water Thrush (*Seiurus* sp.); (1) Rose-breasted Grosbeak *(Hedymeles ludovicianus);* (1) Eastern Meadowlark *(Sturnella m. magna);* (1) Eastern Redwing *(Agelaicus p. phoeniceus);* (1) Clay-colored Sparrow *(Spizella pallida);* (1) Eastern Chipping Sparrow *(Spizella p. passerina).*

REFERENCES

COATNEY, G. ROBERT. 1936—A check-list and host-index of the genus Haemoproteus. Jour. Parasit. **22**:88-105.

COATNEY, G. ROBERT AND ROBERT L. ROUDABUSH. 1937—Some blood parasites from Nebraska birds. Amer. Midl. Nat. **18**:1005-1030.

KRUSE, W. 1890—Über Blutparasiten. Virchows Arch. **121**:359-372.

LEGER, M. 1917—Observations sur quelques Leucocytozoon d' oiseaux de la région de Reims. Bull. Soc. Path. Exot. **10**:28-33.

LEGER, M. AND A. 1914—Les Leucocytozoon: leur dénombrement et essai de classification. Bull. Soc. Path. Exot. **7**:437-447.

MANWELL, R. D. AND CARLTON HERMAN. 1935—The occurrence of the avian malarias in nature. Am. Jour Trop. Med. **15**:661-673.

NOVY, F. G. AND W. J. MACNEAL. 1904—Trypanosomes and bird malaria. Am. Med. **8**:932-934.

———1905—On the trypanosomes of birds. Jour. Inf. Dis. **2**:256-308.

PLIMMER, H. G. 1913—Report on the deaths which occurred in the Zoological Gardens during 1912, together with a list of the blood-parasites found during the year. Proc. Zool. Soc. London: 141-149.

SAKHAROFF, M. N. 1893—Recherches sur les Hematozoaires des oiseaux. Ann. Inst. Pasteur **7**:801-811.

SAMBON, L. W. 1908—Remarks on the avian Hematozoa of the genus *Leucocytozoon* Danilewsky. Jour. Trop. Med. **11**:245-248; 325-328.

A Description of Phyllodistomum caudatum n. sp.*

Gerald M. Steelman

Twenty-two specimens of the common bullhead, *Ameiurus melas* (Rafinesque), from Boomer Creek near Stillwater, Oklahoma, were examined for urinary bladder flukes and found to be infected with a new species of the genus *Phyllodistomum* Braun. Approximately one-third of the catfish were infected; the number of flukes in the infected fish ranged from 1 to 7 with 3 being the most common. A total of 23 worms was found. I propose the name *Phyllodistomum caudatum* for this form. The worm was studied in both live and preserved states. The flukes were fixed in hot 70 percent alcohol, stained in borax carmine, and mounted *in toto*. Serial sections were prepared of one specimen.

Phyllodistomum caudatum n. sp.

Description.—Body composed of definitely demarcated anterior subcylindrical *presoma* and posterior flat, circular, discoidal *opisthosoma*. In cross section the former appears ovoidal, the latter quite flattened. Presoma widest at juncture with opisthosoma which is at level of middle of acetabulum. Extreme posterior portion of body attenuated as a caudal projection. Sensory papillae on suckers, small, numerous. Oral sucker slightly larger than acetabulum; ratio of diameter of oral sucker to that of acetabulum 1:0.93. Oral sucker nearly circular; mouth subterminal. Remains of penetration gland cells small, located at postero-lateral margins of oral sucker. Esophagus somewhat sinuous, varying in form with state of contraction of body. Bifurcation of esophagus anterior to middle of presoma; intestinal rami wide, extending directly posteriad to level of posterior margin of acetabulum, thence postero-laterad to about middle of posterior portion of body, thence postero-mesad, terminating in posterior fourth of body.

Measurements of 5 live specimens in millimeters: length 2.77 (1.97-4.55); presoma, length 1.09 (0.91-1.52), width 0.448 (0.30-0.75); opisthosoma, length 1.68 (1.06-3.03), width 1.508 (0.75-2.72); oral sucker, diameter 0.29 (0.19-0.42); acetabulum, diameter 0.28 (0.19-0.404). Measurements of 10 preserved specimens in millimeters: length 2.68 (1.77-3.68); presoma, length 1.159 (0.86-1.28), width 0.498 (0.34-0.94); opisthosoma, length 1.516 (0.91-2.40), width 1.465 (0.80-2.46); length of caudal projection 0.148 (0.07-0.20); oral sucker, diameter 0.308 (0.22-0.41); acetabulum, diameter 0.289 (0.22-0.34); ovary, length 0.207 (0.15-0.27), width 0.208 (0.14-0.30); anterior testis, length 0.233 (0.20-0.32), width 0.219 (0.14-0.27); posterior testis,

* A contribution from the Zoological Laboratory of the Oklahoma Agricultural and Mechanical College, prepared under the direction of R. Chester Hughes.

length 0.262 (0.20-0.34), width 0.235 (0.20-0.27); eggs, length 0.0322 (0.03-0.035), width 0.024 (0.021-0.026); distance between margin of oral sucker and bifurcation of esophagus 0.25 (0.14-0.47).

Vitellaria well separated from acetabulum posteriorly, irregular and variable in shape, somewhat lobate in some specimens but not distinctly so in others. Vitelline ducts extend directly mesad to join the median ootype. Ovary deeply staining, very compact, divided into from 3 to 6 lobes by deep indentations; ovary dextral or sinistral with approximately equal frequency. Oviduct arises from dorsal surface of ovary and extends antero-mesad to ootype. Laurer's canal present. Uterus arises on anterior side of ootype, curves immediately dorsad, and extends posteriad tracing a sinuous course throughout the posterior portion of body. Uterus chiefly intracaecal with a few extracaecal loops. Eggs numerous, in single or double file in uterus, fully embryonated in distal portions. Testes less compact than ovary, large, at least twice size of ovary in most specimens, deeply divided into from 3 to 6 irregular lobes. Testis I opposite and slightly posterior to ovary; testis II directly posterior to ovary. Vasa efferentia unite anterior to acetabulum. Seminal vesicle located just posterior to bifurcation of esophagus, opens into common genital atrium which communicates with exterior by genital pore located about midway between origin of intestinal rami and acetabulum. Distal end of uterus enlarged, ventral to seminal vesicle.

Live worms white in reflected light; transparent in transmitted light, with ovary, testes, vitellaria, and remains of penetration glands clearly recognizable. Vitellaria of dark appearance because of highly refractile granular content. Vestiges of penetration glands much more elongate than in preserved material. Margin of opisthosoma finely crenulated—crenulations mostly lost in preservation. Active sperms abundantly visible in seminal vesicle and uterus.

Behavior.—Worms attached by suckers to wall of bladder release themselves when bladder is teased open in water. Presoma very active, may be extended to about twice its normal length. Opisthosoma seldom exhibits motility. Movements effect little if any spatial progression. Oral sucker round when body is relaxed, elongated when extended. Suckers may become attached to surface of container or to worm's own body.

Host.—*Ameiurus melas* (Rafinesque).

Habitat.—Urinary bladder.

Locality.—Boomer Creek near Stillwater, Oklahoma.

Type specimens.—Ten specimens, mounted *in toto* in the United States National Museum.

Comparisons with Other Species

With the present form the genus *Phyllodistomum* Braun (including the repeatedly suppressed *Catoproides* Odhner) contains 24 species, 10 of which are North American; five of the latter *(P. carolini, P. lacustri, P. staffordi, P. hunteri,* and *P. caudatum)* are parasites of ameiurids. *Phyllodistomum angulatum* von Linstow 1907, *P. folium* (Olfers 1816), *P. megalorchis* Nybelin 1926, *P. simile* Nybelin 1926, *P. spatula* (Odhner 1902), *P. spatulaeforme*

(Odhner 1902), and *P. superbom* Stafford 1904 differ from *P. caudatum* in being emarginate posteriorly. In this group *P. spatula* and *P. spatulaeforme* have the ovary at the level of the vitellaria and spheroidal eggs of smaller size while the others have eggs larger than those of *P. caudatum*. *P. conostomum* (Olsson 1876), *P. americanum* Osborn 1903, *P. elongatum* Nybelin 1926, *P. acceptum* Looss 1901, *P. linguale* Odhner 1902, and *P. marinum* Layman 1930 differ in that the posterior portion of the body is not distinctly set off from the anterior region and the ratio of the diameter of the oral sucker to that of the acetabulum is smaller. *P. pearsei* Holl 1929 and *P. unicum* Odhner 1902 differ in that the testes are not distinctly larger than the ovary and the body is more slender and elongate. The ratio of the diameter of the oral sucker to that of the acetabulum is much smaller than that of *P. caudatum* in *P. lucustri* (Loewen 1929) and *P. staffordi* Pearse 1924. The above comparisons are based largely upon data tabulated by Lewis (1935); the following comparisons are based on information from the original descriptions. *Phyllodistomum fausti* Pearse 1924, *P. hunteri* (Arnold 1934), *P. lohrenzi* (Loewen 1935), *P. patellare* (Sturges 1897), and *P. singulare* Lynch 1936 differ in that relatively more of the uterus is extracaecal.

Phyllodistomum caudatum is most like *P. carolini* Holl 1929 from *Ameiurus natalis* (Le Sueur) in which (1) the size is smaller, (2) the uterus is much more profusely coiled and extends closer to the margins of the posterior portion of the body, (3) the eggs are smaller and more broadly oval, (4) the ratio of the diameter of the oral sucker to that of the acetabulum is much smaller, and (5) vestiges of penetration gland cells are not mentioned in the description. The most distinctive characteristic of *P. caudatum* is the presence of a tail-like projection at the posterior end of the body; I have found no mention of such an appendage in the descriptions of other species. *P. singulare* is apparently the only species previously described as having remains of penetration gland cells.

REFERENCES

ARNOLD, J. G. 1934—Some trematodes of the bullhead *Ameiurus nebulosus* (Le Sueur). Trans. Amer. Micr. Soc. **53**:267-276.

HOLL, F. J. 1929—The phyllodistomes of North America. Trans. Amer. Micr. Soc. **48**:48-53.

LEWIS, F. J. 1935—The trematode genus *Phyllodistomum* Braun. Trans. Amer. Micr. Soc. **54**:103-117.

LOEWEN, S. L. 1935—A new trematode of the family Gorgoderidae. Jour. Parasit. **21**:194-196.

LYNCH, J. E. 1936—*Phyllodistomum singulare* n. sp., a trematode from the urinary bladder of *Dicampton ensatus* (Eschscholtz), with notes on related species. Jour. Parasit. **22**:42-47.

PEARSE, A. S. 1924—Observations on parasitic worms from Wisconsin fishes. Trans. Wis. Acad. Sci., Arts and Letters **21**:147-160.

STURGES, M. 1897—Notes on *Distomum patellare*. Zool. Bull. **1**:57-69.

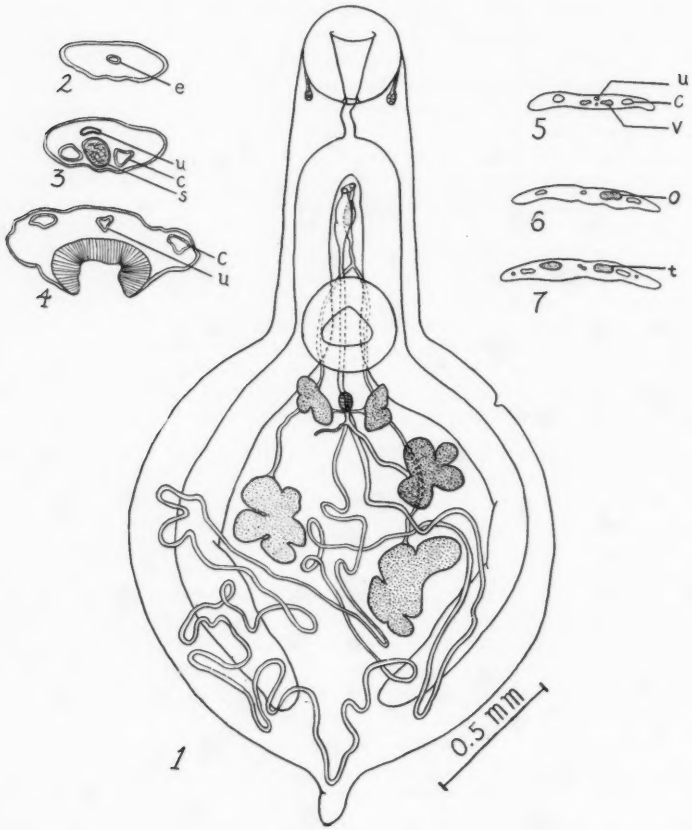

PLATE 1

All figures concern *Phyllodistomum caudatum* n.sp. and were made from preserved material with the aid of a camera lucida. Figures 2, 3, and 4 are drawn to the same scale, and figures 5, 6, and 7 to the same but smaller scale. Abbreviations: c—caecum, e—esophagus, o—ovary, s—seminal vesicle, t—testis, u—uterus, v—vitellaria.

FIGURES

1. Ventral view.
2. Cross section at level of esophagus.
3. Cross section at level of seminal vesicle.
4. Cross section at level of acetabulum.
5. Cross section at level of vitellaria.
6. Cross section at level of ovary.
7. Cross section at level of testes.

A Remarkable Infection of Tapeworm Larvae in a Whipsnake*

W. Eugene Hubbard

On May 16, 1937 a large female specimen (4.5 feet long) of *Coluber flagellum flavi-gularis* (Hallowell) was captured in the "Gyp Hills" about 7 miles north of Watonga, Oklahoma. The snake was kept alive through the summer without food, though watered well, and examined on October 9. Twenty lung mites previously described** as a new species and genus, *Ophiopneumicola colubri,* were found. The snake also harbored over 1000 plerocercoids encysted in connective tissues along the entire length of the body. The worms were most numerous in the peritoneum and mesenteries adjacent to the stomach and intestine. The parasites were also found in the muscles of the body proper and in the tail. The cysts were of variable size and contained from 1to 4, most often 2 or 3, larvae. The larvae, often within the same cyst, showed markedly different degrees of development. In the larger worms the scolex was well developed, deeply invaginated, and provided with 4 prominent muscular suckers. The smallest worms were entirely devoid of scolices.

Measurements, recorded in millimeters, are those of 10 specimens free from pressure. Fresh cysts, length 1.75 to 4 (average 2.56), width 1 to 2 (average 1.6); preserved worms removed from cysts, length 0.95 to 5.75 (average 2.67), width 0.7 to 1.5 (average 1.04).

Over 100 of the larvae were fed to a kitten about one month old but no tapeworms were found in the autopsy 30 days later.

PLATE 1

All drawings concern a tapeworm larva found encysted in *Coluber flagellum flavigularis* (Hallowell). Figures 2 and 7 were drawn with the aid of a camera lucida. The others were drawn with the aid of a micro-prejector, all to the scale indicated in figure 4. All except figure 2 were drawn from living material.

Figs. 1, 4, and 5. Cysts containing 2, 4, and 2 larvae respectively.
Figs. 3 and 6. The two larvae removed from the cyst represented in fig. 1.
Fig. 2. Scolex of a preserved larva.
Fig. 7. Field of microscope showing calcareous corpuscles in the cortical parenchyma adjacent to the dorsal surface. A similar pattern occurred in the ventral cortical parenchyma.

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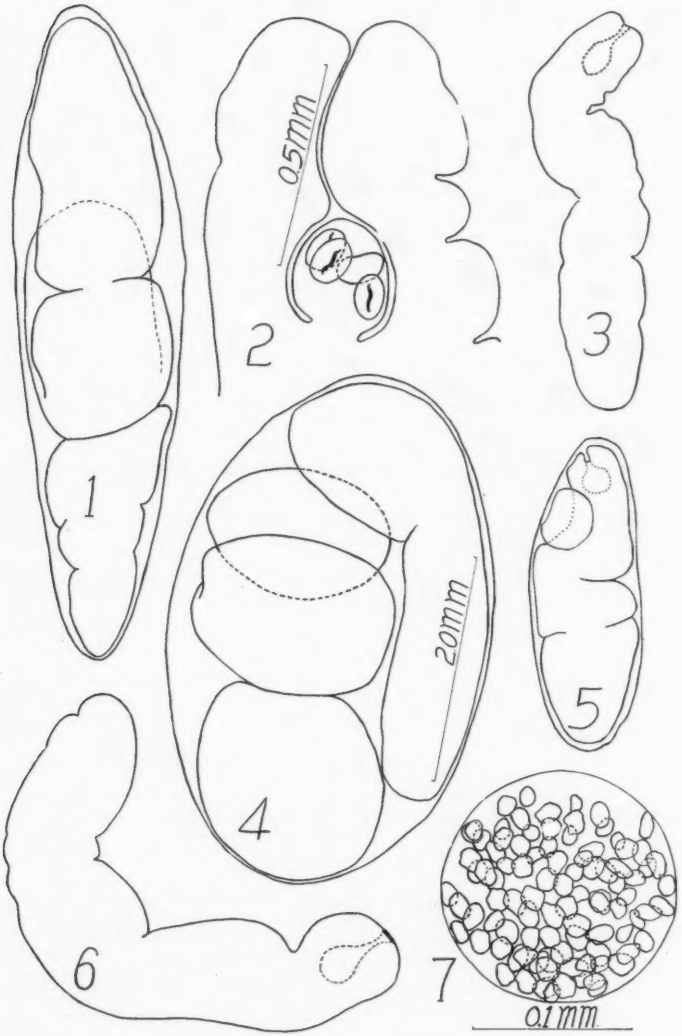
* Contribution from the Zoological Laboratory, Oklahoma Agricultural and Mechanical College, prepared under the direction of R. Chester Hughes.
Identification of the snake was confirmed by Dr. Charles E. Burt, Southwestern College, Winfield, Kansas.

** Hubbard, W. E., 1938, *Ophiopneumicola colubri* n.g., n.sp., a lung mite from a snake. Trans. Amer. Micr. Soc. **57**:(in press).

PLATE 1



Tardigrada from North America

G. B. Mathews

The distribution of Tardigrades is worldwide. All of them are hygrophilous, but some of them are of necessity restricted to life in the water and are distinguished as Marine or Fresh Water Tardigrades. These Waterbears are found in all parts of the globe, in the Arctic as well as in the Antarctic regions, among the mosses and lichens collected at a height of 6,000 m., and among water plants. The general distribution of the animalcules is caused by the Anabiosis and the wind which carries these minute forms of animal life into every nook of our planet. Tropical countries do not seem favorable (as far as number of individuals and species are concerned) to productive Faunas of Tardigrades. The largest number of these animalcules found in a bed of dried moss was 22,000 per gm.

Illiger, Cuvier, Burmeister, and others originally applied the name Tardigrades to a group of mammals, and Spallanzani, in 1776, employed the name "Il tardigrado" for these animalcules. Other appelations used in the course of time, were Brucolino, "Kleiner Wasserbaer," by Goeze in 1773; Sloth by Dalyell in 1830; Urslet. The present name "Waterbear" dates back to Huxley, in 1869, who also considers the name "Watersloth" as an appropriate one. All of these names, however, indicate the characteristic movement, a distinguishing mark of these animalcules.

In the system of animal life Tardigrades are classified as: *Prostomia articulata (Annelida* and *Arthropoda)* and are listed between the *Protracheata (Onychophora)* and the *Eutracheata (Myriapoda, Chilopoda, Apterygogenea, Insecta),* (Claus-Grobben). The group of Tardigrades is classified by Marcus as follows:

I. Ordo HETEROTARDIGRADA
   A. Subordo: ARTHROTARDIGRADA, 2 families
   B. Subordo: ECHINISCOIDEA, 2 families, of which the second *Scutechiniscidae* embraces the genera *Parechiniscus, Eschiniscus,* and *Pseudechiniscus.*

II. Ordo EUTARDIGRADA. 1. family: *Macrobiotidae (Macrobiotus, Hypsibius)*
   2. family: *Arctiscidae (Milnesium).*

Within the last 20 years the knowledge in reference to Physiology and classification of Tardigrades has increased very widely. The growth of more or less good species, 50 in 1916 and now 270, shows the great interest that has been taken in these animalcules. Nevertheless, the antiquated views expressed even in more modern textbooks betray how little is known about them.

Tardigrades distinguish themselves by their peculiar ability to carry on life in four distinct phases; their life is either active or latent, latent under the form of Anabiose, Asphyxy, and Encysting (Anabiosis, Asphyxia, Encystation). As early as 1776, Spallanzani had observed these peculiar powers, but much later, the Anabiose became a subject for varied experimentation. Whenever the normal supply of oxygen decreases, and the surroundings grow dry, signs of life diminish; the integument becomes wrinkled on account of the surface reduction, and the body begins to shrink. In this shape of a little cask, you can barely distinguish anything else than legs and eyes.

If, however, the surroundings of an anabiotic Waterbear become moist, then the animalcule returns to active life. This process can be pursued in a laboratory quite easily, by means of a microscope. The shrunken body begins to swell, the legs come forth, and within a few minutes' up to an hour's time, the animalcule has returned to active life, and crawls about amazingly like a bear. In the laboratory, a single animal has been observed making this return from anabiotic to active life, fourteen times.

If the animalcule is kept in a small moist chamber, you may notice that in about two days the animalcule moves no more; it is stretched out to the maximum, for the cells of the epidermis have lost their controlling power over the water-content. The animalcule may continue in this phase for five days, and if no change sets in, it will die. This particular phase, called Asphixia, makes the study of these animalcules very interesting and easy, for you need but keep these tiny animals for a few days in a wet chamber or hanging drop and you can make your observations on a completely stretched out, motionless animal.

In the laboratory the animalcules were preserved in active life for seven months; during this time they shed their skin almost every four weeks—this process can be promoted by chemical injury. Nothing is known about the duration of life of these animalcules, when found in nature itself. Animals have been discovered, which, after an Anabiotic life of six and one-half years, passed over to an active one, as soon as the normal supply of moisture was present. It has not yet been decided whether in this Anabiotic phase there was a complete cessation of metabolism, or whether the metabolic processes were reduced to a "Vita minima." In this phase of life the animalcules display an extraordinary force of resistance against physical, chemical, and optical influences; they can suffer the extreme cold of —200 C. without injury for seven months, and then after being placed in liquid Helium of —271.5 C. for four hours, can still be restored to active life; high temperatures do not prove fatal either, for a half-hour-stay in a temperature of 96 C. did them no harm. A pressure of 1,000 atmospheres has been proved not to be lethal; experimentation with a vacuum and an exsiccator has also proved the great resisting power of the Waterbears; even such various gases as H, N, He, CO_2, H_2S did not prove disastrous to these tny animals; SO_2 however, is an exception. The animalcules likewise display a surprisingly great resisting power against UV-rays, Radium, X-rays; during the past year tests were made to ascertain the effects of Ultra-sound waves on Milnesium. It is impos-

sible as yet to state what does eventually destroy their lives or make metabolism impossible; it may be that signs of decay appear at the slightest change of substance, or a non-mixing of the plasmacolloids, an ageing of the same, or a complete withdrawal of moisture. Hesse compares this phase with that of a clock, that has been wound up, but has its pendulum stopped.

The Tardigrada are of the bilateral symmetrical type. There are four pairs of stelechopodia, the last of them is terminal. The distal part of each of the legs shows a large variety in differentiation, which is of high importance in classification. The claws, of cuticular origin, are symmetrical in the Heterotardigrada, which are homodactylous and homonychous, or asymmetrical as in the heteronychous Eutardigrada. In some species of Macrobiotus a cuticular outgrowth is found at the base of the claws called a lunula, while most of the Scutechniscidae are provided with a more or less denticulated cuff on the terminal legs. The cuticle is smooth in most of the Eutardigrada, while the Scutechniscidae have a cuticle composed of plates. These may be granulated and often bear hair-like or spinous outgrowths. The terminal mouthopening is sometimes ventrally located and may be surrounded by rings or lamellae. The buccal cavity opens posteriorly into a more or less narrow chitinous mouthtube. At the distal end of it are (Macrobiotidae) sometimes cuticular swellings, the apophyses. On either side of the mouthtube one finds a calcareous pointed tooth, the stylet. The teeth are used in piercing the cell-walls of plants, or in some instances, of animals. The movements of these stylets are controlled by muscles which either protrude or retract the teeth or move them in any direction. Clavicular shaped tooth-bearers support the stylets (esp. Eutardigrada). The contents of the cell is sucked in by a round or spherical muscular pharynx. It shows a constance of cells, since in the Eutardigrada are 25 epithelial cells and 39 muscular ones, while in the Heterotardigrada there are 27 epithelial cells and 24 muscular ones. In the pharynx are a number of chitinous masticating plates (Macrobiotidae), the macroplacoids or bacilla. They are arranged in three double rows and the number of them is of high taxonomic value. A small terminal granule is called a microplacoid or komma. The pharynx may pass almost immediately into the mid-intestine or a short oesophagus connects them. The narrow rectum receives the products of the excretory organs, two Vasa malpighii and a dorsal gland in the Eutardigrada where the cloaca opens ventrally as a transversely placed orifice. The anus in the Heterotardigrada is a longitudinal slit. In the body are found reserve cells (blood corpuscles of earlier authors) which vary in number and size according to age and nutrition. These are composed of fat, starch, or glycogen. This stored material will be used up during periods of low food supply or moulting. Eyes, or better, eyespots of the ocellus type may be present. The pigment of them is black, except in rather few Scutechiniscidae where it is red. Circulatory and respiratory organs are lacking and no connective tissue is formed.

The nervous system consists of a cerebral ganglion (supraoesophageal), a pharyngeal ganglion (suboesophageal), and a chain of four bi-lobed ventral ganglia. The muscles are metamerically arranged.

Though Tardigrada are dioecious animals, the males of some species are not yet known. In both sexes the single gonad is located dorsally above the digestive tube. The gonoducts, a pair of Vasa Deferentia or a single oviduct respectively open at a ventral preanal gonopore in the Heterotardigrada or into the cloaca in the Eutardigrada. In some of the Macrobiotidae a receptaculum seminis is recorded in specimens collected during fall or winter. There are two kinds of fertilization: an external one observed in aquatic forms, the sperm being introduced into the egg containing cuticle, and an internal one in terrestrial forms. The eggs vary in size from 42 x 30 μ to 157 x 176 μ. They are deposited free, single or in small groups as in Echiniscoides, Macrobiotus, and some of the Hypsibius. In this case they are provided with specific outgrowths by which the eggs remain attached to the substratum, as leaves of mosses, etc. In the other forms all eggs are deposited at once (3-35) into the cuticle during moulting. The diploid number of chromosomes is 10, 12, or 14.

The holoblastic egg undergoes a total adequate segmentation. The type of gastrulation is that of a coeloblastic delamination. After the formation of the archenteron the proctodaeum develops by an invagination of a portion of the ventral ectoderm. The stomodaeum is formed from an invagination after further incurvation of the embryo. By the latter median invagination the archenteron divides into two lateral diverticula, which for the time being remain united with the archenteron. From these originate the two coelomic cephalic sacs. From the mid-intestinal wall rise four pairs of enterocoelic pouches. They soon undergo disaggregation, except the fourth pair from which the sacgonad develops. The supraoesophageal ganglion starts from a thickened part of the cephalic ectoderm, while the suboesophageal ganglion originates from a multicellular ventral ectodermal layer. The stomodaeum divides later on by a constriction into a caudal and rostral part, which in their turn form the pharynx and the mouthtube with the salivary glands. From the latter develops the stylet system. Where mid-intestine and proctodaeum meet are the malpighian glands. At the end of the embryonic development (from 3-40 days) the young waterbear makes a hole into the egg shell with the help of its stylets and crawls out. It resembles in this stage an adult, except in size and the development of some organs. Small differences in the outfit of the pharynx characterize the young Macrobiotidae, while the young Scutechiniscidae possess only two claws and plates with poorly developed outgrowths. By growth they acquire the characters of the adults. Since in the Tardigrada there is a cell constance, the growth of the individuals is accomplished, not by cell division, but by enlargement of the cells.

In order to obtain Tardigrades, one must gather the plants on which they are found, e.g. lichens, mosses (not too small), especially such plants which have soft leaves, e.g. Hypnaceae, Pottiaceae, Grimmiaceae, and Hepaticae. You will find the herbivorous tradigrades on the rosetta-like leaves of the Angiosperms, also; it is best to select these plants from trees or rocks that are not too close to the city or much traveled streets. City roofs have comparatively few Tardigrades. The small yellow lichen, Xanthoria, mostly on trees, is the most suitable plant to start out with, for it usually houses more than

one species. In order to restore the animalcules from their Anabiose to active life and to full development, you must take the pieces of the plants, which you have collected, and lay them into a petridish, or watchglass filled with water; after half an hour the plants are rinsed, so that the animalcules fall out; you can then search for the Tardigrades with a good magnifier or better with a binocular (80x). If the pieces of the plants are too large, place them into a funnel filled with water, whose lower end is to be closed with a clamp; after a sufficient interval of time, squeeze the water out of the plants and let it drip off; you may centrifuge the sediment, as also the contents of the petridish, and you will find the Tardigrades above the rougher material in the test-tube; in this way you can obtain a greater concentration of the bryophilous fauna. You can make your observation of the sediment in the petridish, or you can bring it, by means of a pipette, to a pane of glass, 6 x 8″, where you will spread it out in long rows about .2″ wide. In this manner hardly any of the sediment will be overlooked, and through the microscope can then be seen a sector of cryptozoic bryophilous life: free living nematodes, Rotatoria, and Protozoa. Among these Tardigrades can be seen perhaps also their eggs and occasionally Acarina. With a micro-pipette you will take the little animals or their eggs on a slide for studies with high power. The best and simplest mixing fluid is a four per cent neutral formalin solution. Water-tardigrades may be found too among waterplants (algae, flowers) or on marine plants (Enteromorpha, Dictyota, etc.) whose washings are investigated. Mosses and lichens found in herbariums are also suitable for investigation. Even if the animals are pretty much decayed, you can still recognize their general structure after the water has bloated them; the same holds good also for their eggs.

A. S. Packard (1873) gives us the earliest information about Tardigrades in North America. Packard mentions Water-Tardigrades from Gloucester, Maine; he mentions still another species belonging to the same genus "but supplied with apparently longer and straighter claws." L. Beal (1880) mentions Water-Tardigrades. He asserts that they resemble those of Packard's which originate in the same aquarium. His figures show the details of the egg-deposit. John Murray, one of the greatest Tardigrade-explorers, mentions in his list (1907) an Hypsibius from America, without however designating any particular place thereof. In the following year, 1908, mention is made by Richters of Tardigrades from British Columbia. J. Murray (1910) published a list of Tardigrades that were found in the material of E. Shackleton's expedition, 1907-1909. In 1917 W. P. Hay published a good description of a marine Tardigrade from Beau Fort, North Carolina. In 1928 E. Marcus makes mention of Macrobiotidae from Washington, D. C., and from the Niagara Falls.

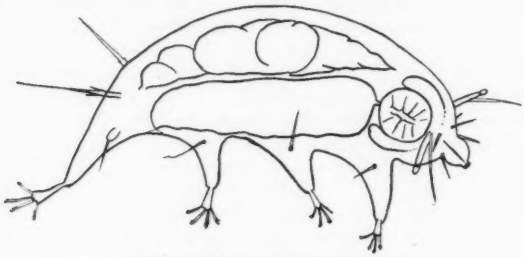
The species recorded from North America, north of the Mexican border are.

Heterotardigrada

Subordo Arthrotardigrada

Batillipes mirus Richters, syn. *B. caudatus* W. P. Hay; Beau Fort, N. Carolina. 1917.

Bathyechiniscus tetronyx G. Steiner. This species recorded from the antarctic and Sargasso Sea was found in washings of Dictyota from the coast of California. The length of the adult individuals with well filled gonads varied from 140-204μ, total length of stretched animals. The data of a specimen of 204μ total length are. Clava :12.8μ, cirrus lateralis :28μ, cirrus medianus :11μ, cirrus medialis internus, externus :13μ oseophagus 19 x 16μ, caudal spine surrounded basally by a sheath 35μ, distance from final spine to end of terminal stelechopodia 64μ, length of median claw of the latter 13μ. Just aside this biggest individual a young was found 53μ in length, 45μ from head to caudal spine. Each leg had four claws. Eggs were not observed, but from the young we can conclude that they should be rather small about 30μ. The seven adult indiivduals were all well fed and the mid-intestine was filled with green foodstuff.



Bathyechiniscus tetronyx Steiner.

Subordo ECHINISCOIDEA

Fam. *Scutechiniscidae*

Genus *Echiniscus* (C. A. S. Schultze)

Echiniscus (Bryodelphax) parvulus (Thulin), Syn. *E. intermedius*, American variety J. Murray, 1910, p. 161, t. 20, f. 52. Br. Columbia, Vanc. Isl.

E. (Hypechiniscus) gladiator J. Murray, 1910, p. 111, 160, t. 12, f. 51. Br. Columbia, Vanc. Isl. and from the same place Richters, 1908, p. 204.

E. arctomys Ehrenberg, several specimens from Vermont, Brandon, 190-205μ caudal plates with facets. East Troy, Wisc., leg. Mathews.

E. sylvanus J. Murray, 1910, p. 160, t. 20, f. 49. Canada, Ontario.

E. canadensis J. Murray, 1910, p. 162, t. 20, f. 47. Br. Columbia, Vanc. Isl.

E. reymondi E. Marcus, cf. E. spec. J. Murray, 1910, p. 166, t. 20, f. 45. Br. Columbia, Vanc. Isl., Victoria, Marcus, 1929, p. 326, f. 163.

E. bisetosus F. Heinis, det. J. Murray, 1910, p. 164, t. 20, f. 50. Br. Columbia, Vanc. Isl.

E. oihannae F. Richter, det. Murray, 1910, p. 163, t. 20, f. 48. Br. Columbia, Vanc. Isl.

E. merokensis F. Richter, from S. Juan Isl., Wash., all individuals with typical dorsal outgrowths above c and d; from Longmires Springs, Wash.

Genus *Pseudechiniscus* Thulin

Pseudechiniscus suillus (Ehrenberg) from S. Catalina Isl., Cal., Windham Bay, Alaska, Vermont, Brandon.

EUTARDIGRADA

1. Fam. *Macrobiotidae*

Genus *Macrobiotus* (C. A. S. Schultze)

Macrobiotus occidentalis J. Murray, 1910, p. 169, t. 19, f. 54a-54b. Br. Columbia, Vanc. Isl.

M. intermedius L. Plate, det. Murray, 1910, p. 171, Canada, Ontario.

M. harmsworthi J. Murray, 1910, p. 169, t. 18, f. 31. Canada, Ottawa.

M. virgatus J. Murray, 1910, p. 174, t. 21, f. 55a. Br. Columbia, Vanc. Isl.

M. hufelandii C. A. S. Schultze, det. Murray, 1910, p. 166. Canada; Richters, 1908, p. 205, Br. Columbia, Vanc. Isl.; Marcus, 1929, p. 147. Washington, D. C. A good population was found from S. Juan Isl., Wash., also at Ephraim, Wisc., and on Isle Royal, Michigan. East Troy, Wisc., leg. Mathews.

M. echinogenitus Richters, det. J. Murray, 1910, p. 167. Br. Columbia, Canada.

Genus *Hypsibius* (Ehrbg.) Thulin emend.

Hypsibius (Isohypsibius) tuberculatus (Plate), det. Murray, 1910, p. 173. Br. Columbia.

H. (I.) schaudinni (F. Richters), three specimens from Galveston, Texas, no microplacoid, macroplacoids caudad increasing.

H. (I.) prosostomus (G. Thulin), from Isle Royal, Michigan.

H. (I.) canadensis (J. Murray), *Macrobiotus c.* Murray, 1910, p. 171, t. 21, f. 61a-d. Br. Columbia, Canada, Rocky mountains. The pharynx of individuals found at S. Satalina Isl., Cal., were rather round.

H. (I.) augusti (J. Murray). The specimens L. Beal (1880, p. 593-594) mentions belong most probably to this species since the arrangement of the claws (Fig. 3) as figured by Beal fit to figures as given by Marcus (1936 p. 257, f. 252 F. b), and the number of eggs as observed by Beal, 26 apparently exclude *H. dujardini* and *M. macronyx*. New Gloucester, Me.

H. convergens (Urbanowicz), det. Murray, 1907, p. 680, N. America; Marcus 1928, p. 206 from Niagara Falls.

H. arcticus (J. Murray), 1910, p. 171, t. 14, f. 2a-f. Br. Columbia, Vanc. Isl.

H. oberhaeuseri (Doyère), det. Murray, 1910, p. 171. Br. Columbia. Specimens from S. Catalina Isl., Cal., had a granulated abdomen. East Troy, Wisc.

H. areolatus (J. Murray), 1910, p. 176. Br. Columbia, Vanc. Isl., Rocky Mountains, Canada.

H. (Diphascon) scoticus (P. Murray), 1910, p. 176. Br. Columbia, Vanc. Rocky Mountains, Canada.

H. (D.) oculatus (J. Murray) forma *vancouverensis* Thulin, syn. *D. canadense* J. Murray, 1910, p. 176, t. 21, f. 62a-c. Br. Columbia, Vanc. Isl.

H. (D.) alpinus (J. Murray), syn. *D. alpinum* J. Murray 1910, p. 175, t. 14, f. 3. Rocky Mountains, Canada.

H. (D.) chilenensis (L. Plate), det. Murray, 1910, p. 175, t. 15, f. 11a-b. Rocky Mountains, Canada.

As species incertae sedis:

Hypsibius americanus (A. S. Packard), syn. *Macrobiotus americanus* A. S. Packard, 1873, p. 741, f. 181 a-c. The description and figures are not sufficient for classification. New Gloucester, Me.

2. Fam. *Arctiscidae*
Genus *Milnesium* Doyère

Milnesium tardigradum Doy., det. Richters, 1908, p. 205. Br. Columbia, Vanc. Isl., J. Murray, 1910, p. 166. Ontario, Canada. Rather transparent specimens were found at Friday Harbor, Wish., those from S. Juan Isl., Wash., were of intermediate pigmentation. Techny, Ill., leg. Neuhaus. East Troy, Wisc., leg. Mathews.

Summary

The systematic position of the Tardigrada is between Protacheata and Eutracheata. The three phases of latent life, anabiosis, asphyxia and encystment rendered them a favorable object for physiological experiments. The waterbears show a remarkable resistance against influences of chemical, physical and optical kind not yet observed in the same combination and extent in other metazoa. Sixty-five years ago the first Tardigrade was described from U.S.A. Now, 32 species are known from North America, north of the border line of Mexico, not including several species spec. Thirty species are terrestrial, one is a fresh water form and two are marine.

The writer wishes to thank Dr. P. C. Standley the curator of the herbarium at the Field Museum, Chicago, Ill., for his kind permission to study the mosses and lichens of that collection.

St. Mary's Mission House,
Techny, Ill.

REFERENCES

The literature about Tardigrada comprises more than 210 titles. A complete list of them up to 1929 is given in Marcus (1929, p. 576-584), the standard work about Tardigrada. Only those papers are listed below which deal with the occurrence of Tardigrada in North America, (except Baumann).

BAUMANN, H. 1929—Zur Asphyxie der Tardigraden. Zool. Anz. **86**(1/2):44-48.

BEAL, F. E., JR. 1880—Tardigrades and eggs. Amer. Nat. **14**(8):593-594, figs. 1-3.

CUÉNOT, L. 1932—Tardigrades. Faune de France, pars 24.

HAY, W. P. 1917—A new species of bear-animalcule from the coast of North Carolina. Proc. U. S. Nat. Mus. **53**:251-254, tab. 33.

MARCUS, E. 1928—Bärtierchen (Tardigrada). In: Dahl, F., Die Tierwell Deutschlands etc., Teil 12.

———1929—Tardigrada. In: Bronn, Klassen und Ordnungen des Tierreichs. Bd. 5, 4. Abt., Buch 3.

———-1936—Tardigrada. Das Tierreich Lfg. 66.

MURRAY, J. 1907—Arctic Tardigrada. Trans. Roy. Soc. Edinburgh **45**(3):669-681 tb. 1, 2.

———1910—Tardigrada. In: Report on scientific investigations of the British antarctic expedition 1907-1909 (E. H. Shackleton) **1**(5):81-185, tb. 14-21.

PACKARD, A. S. 1873—Discovery of a Tardigrade. Amer. Nat. **7**(12):740-741, fig. 181 a-c. Salem, Mass.

RICHTERS, F. 1908—Beitrag zur Kenntnis der Moosfauna Australiens und der Inseln des Pacifischen Oceans. Zool. Jahrb. Syst. **26**(2):196-213, 4 figs., tab. 17.

Records of Distribution of Species of Isopods in Central and Southern United States, with Descriptions of Four New Species of Mancasellus and Asellus (Asellota, Asellidae)

J. G. Mackin and Leslie Hubricht

In an effort to furnish data bearing on the problems of geographic distribution of the Isopoda, the following records are published. It seems highly desirable that more locality records be made available, since in this manner only may exact extent of distribution be ascertained.

It should be pointed out that specific determinations of some forms in the genera *Asellus* and *Mancasellus* are attended with much difficulty. This is due to the fact that in most descriptions up to date stress has been laid on certain characters which are so broad that they are generic in value rather than specific, and conversely, on characters so variable that at most only local races may be defined by them, or only growth stages. As an example of the former, we cite the descriptions of mouth parts, and of the latter, number of segments in the antennae, and relative length of uropods.

In a group in which the studies have been so scattered and uncorrelated, it is inevitable that there should be wide discrepancies of opinion as to what constitute characters of family, generic and specific rank, and value of various specific characters in separation of species. There are certain principles which should be considered carefully when describing species belonging to the genera *Asellus* and *Mancasellus*. These are, first, determination of, and deletion of, generic characters and those of greater rank, second, specific characters should be used in such a manner as to utilize variational data rather than allow them to be confusing factors.

In the specific descriptions in this paper certain customary "specific" characters have been intentionally omitted, such as proportions of the peduncular segments of the antennae. Such characters have been found to be more confusing than helpful, for variations of interspecific nature are slight, while growth variations are greater.

Various European workers have used the characters of the male pleopoda to good advantage (Dudich, Tattersall, Racovitza, etc.). We find these more reliable than any other specific characters. For this reason, descriptions are largely based on the males. In particular the tip of the second pleopoda, endopodite, presents definite characters upon which determination may be based with a fair degree of confidence. Care has been taken to utilize these characters to their fullest extent, mainly by careful drawings.

The technique of study has consisted in staining with acid fuchsin, dis-

secting, and mounting the parts and appendages in balsam. The more minute appendages have been mounted in such a way as to allow study with the high power. In such a manner only may accurate observations be made.

Family *Asellidae*

Asellus communis Say

Localities.—ILLINOIS: MADISON CO.: northeast end of McDaniel Lake. ST CLAIR CO.: marsh, 5300 State Street, East S. Louis. MONROE CO.: Moredock Lake, 2 miles north of Valmeyer. MISSOURI: ST. CHARLES CO.: temporary pond, 0.5 mile north of St. Charles. ST. LOUIS CO.: temporary pond, Benbush; temporary pond, 2 miles north of Fenton; permanent pond, east of Morschels; temporary pond, Buder Park, 1 mile southeast of Valley Park; slough of Mississippi River, 1 mile south of Grimsby. FRANKLIN CO.: Elm Spring, Meramec State Park, 2 miles east of Sullivan; temporary pond, 2 miles south of Gray Summit. ARKANSAS: LAWRENCE CO.: pond. LOUISIANA: NATCHITOCHES PAR.: Black Lake, 6 miles northeast of Campti. OKLAHOMA: TULSA CO.: Mohawk Park. POTTAWATOMIE CO.: pond, near Tecumseh.

In the vicinity of St. Louis this species is found abundantly in temporary ponds, rarely in permanent bodies of water.

Asellus dentadactylus sp. nov.

Description.—A small mottled species, greyish-brown in color, not exceeding 10 or 12 mm. in length The head is without lateral flanges; flagellum of the antennules with about a maximum of 13 segments. Antennae not quite as long as the body, with about 70 segments in the flagellum of the largest specimen.

The gnathopoda are very much like those of *Asellus communis* (see Racovitza 1919). The dactyl has a large triangular process near the base (Fig. 5), which is the most distinctive characteristic. Note in the armature of the propodus the wide thin flange or cutting edge of the palmar margin; the larger of the two palmar processes is a continuation of this flange. Also the diminishing series of heavy spines at the heel of the palm.

The dactyl of the last peraeopoda has 3 spines below, and a tuft of 4 or 5 long hairs or setae above, near the base of the claw.

The characters of the first pleopod of the male are shown in Fig. 3. The concave outer margin of the second segment is characteristic. There are only a few minute setae along this margin. The coupling hooks of the basal segment vary in number from 3 to 5. The long setae at the distal end of the second segment vary from 5 to 7 in the specimens examined. The basal segment of the second pleopoda (Fig. 6) is distinctly oblong, with the internal distal angle deeply cut away. At the angle there are sometimes several minute setae, and usually 3 long setae. Characteristic of the endopodite are, first, the long and narrow basal external process, second, the truncate tip with wide opening (Fig. 4). In the specimens studied the setae of the distal seg-

ment of the exopodite varied from 11 to 20. The setae of the proximal segment vary from 0 to 6.

The shapes of the pleotelson and uropoda are shown in Fig. 8. The margins of all segments are thickly spined as is the pleotelson. In the figure the uropod does not exceed the pleotelson in length, in some specimens however, the uropod is somewhat longer in proportion, up to $1\ 1/3$ times the length. In all specimens the uropoda are heavily spined as shown, and the proportions of the endopodite to expodite about the same.

This species is much like *Asellus intermedius* and probably will be confused with it. The male pleopoda furnish the best characters for separation. In the first pleopoda, the very long setae of the tip, so conspicuous in *A. dentadactylus* are absent in *A. intermedius*. The tip of the endopodite of the second pleopoda in *A. intermedius* is equipped with 2 processes, absent in *A. dentadactylus*. *A montanus* of this paper is also closely related, but this species is distinguished from any other by the spiral-like tip of the copulatory organ.

Cotypes.—U. S. National Museum, catalog number 74841; and collections of the authors.

Localities.—ARKANSAS: JEFFERSON CO.: small creek, 0.5 mile south of Locust Cottage (Type locality). LOUISIANA: NATCHITOCHES PAR.: among dead leaves in a small creek below an artificial pond, property of Miss Caroline Dorman, 2 miles south of Saline.

Asellus incisus Van Name

Localities.—MISSOURI: STONE CO.: spring, 300 yards from entrance to Marvel Cave. BARRY CO.: Roaring River, Roaring River State Park.

Asellus montanus sp. nov.

Description.—This species attains about 12 mm. as maximum body length. The color pattern is a mottled, rich reddish-brown with lighter yellowish spots on the head and thoracic segments, and a uniform brown on the pleotelson. Sometimes with a triangular dark area on the head, but rather variable in detail.

The first antennae vary in flagellar segments up to about 12. The second antennae are about as long as the body, but may exceed that length. The largest specimen (a male) had 97 segments in the flagellum.

Fig. 1 shows the armature of the male gnathopod (left inside view). Note the thickened basal portion of the dactyl, two distal processes of the palmar edge of the propodus, one blunt and the other acute and triangular. Usually 2 heavy spines at the base of the palm, but somewhat variable in this respect. Other characters of the gnathopod are not significant. The dactyl of the last peraeopoda with about 2 short ventral spines proximal to the claw, and usually 2 setae on the dorsal side.

The male pleopoda set this species off sharply from related forms. The first pair (Fig. 2) has only 2 to 4 long setae distally, with more than a dozen

short ones. Note also the row of minute hairs on the inner margin. Coupling hooks vary from 4 to 6. The basal segment of the second pleopoda (Fig. 10) is nearly square and not much cut out at the distal inner angle, at which point there are 2 setae. The exopodite has up to 10 long setae, and a much larger number of small ones along the inner margin of the segment. The form of the endopodite is diagnostic for the species. The tip is curved inward and has the appearance of being twisted into a spiral (see detail, Fig. 9).

There is much variation in the proportions of the uropoda and the pleotelson. In most average specimens the uropoda and the pleotelson are of about equal length; in the large males the former may be more than 1½ times the length of the latter. The basal segment and the endopodite maintain a nearly constant ratio, that is the basal segment is slightly shorter. The exopodite is in most specimens ⅔ to ¾ as long as the endopodite, but in the larger specimens (male) the proportions are as shown in Fig. 7.

This species closely resembles *Asellus intermedius* Forbes, differing in that the latter has only 1 distal process of the palmar margin of the gnathopoda, while *Asellus montanus* has 2; the tip of the second male pleopoda endopodite in *A. intermedius* has 2 slender processes while *A. montanus* has the peculiar spiral described above. In *Asellus communis* the tip of the copulatory organ is not equipped with the processes, but is gently curved toward the exopodite, not spiraled, while in *A. montanus* it is curved toward the median line and is spiraled.

Cotypes.—U. S. National Museum, catalog number 74842; and collections of the authors.

Localities.—ARKANSAS: LAWRENCE CO.: roadside slough, 2 miles southwest of Minturn. SCOTT CO.: creek, Y-City, 4 miles south of Boles (Type locality). OKLAHOMA: LEFLORE CO.: stream near Big Cedar; tributary of the Fourche Maline River, 6 miles west of the Oklahoma-Arkansas border. LATIMER CO.: small stream 5 miles north of Wilberton.

Asellus intermedius Forbes

Locality.—LOUISIANA: LAFOURCHE PAR.: among aquatic plants, Bayou Boeuf, Kraemer.

Asellus brevicaudus Forbes

Localities.—ILLINOIS: ST. CLAIR CO.: Stemmler's Cave, 2 miles south of Bluffside; spring, 0.3 mile south of Falling Spring. MONROE CO.: spring, 2 miles north of Fountain Gap; Wilson Creek, southeast of Columbia; spring, 2 miles east of Waterloo; Morrison's Cave, 2 miles south of Burksville. MISSOURI: ST. CHARLES CO.: Cole Creek, 2 miles west of St. Charles. ST. LOUIS: spring, Carondelet Park. ST. LOUIS CO.: spring, 1 mile north of Oakville; spring on bluff, 0.5 mile east of Hine; spring, 3.5 miles east of Eureka; spring, 0.6 mile northwest of Fern Glen; small spring on bluff, 1 mile south of Grimsby; spring on Glencoe creek, 4.1 miles northwest of Glencoe Station; outlet of drain, Osage Hills Country Club, Kirkwood. JEFFERSON CO.: small spring at foot of hill, on tributary of Selma Creek, 0.7 miles north-

northwest of Selma; spring, 1.7 miles south of House Springs; small spring, 1 mile west of Horine; large spring, 1.8 miles east of Antonia; small spring, 1.5 mile north of Antonia. FRANKLIN Co.: La Jolla Spring, 3.5 miles southeast of Stanton; spring, Port Royal; spring, 2 miles south of Gray Summit. BOONE Co.: spring, 2 miles south of Columbia. CAMDEN Co.: Hahatonka Spring. ARKANSAS: LAWRENCE Co.: York Spring.

Specimens from the caves in St. Clair and Monroe Counties, Illinois, differ from the typical form in being broader in proportion to length and in having the pigmentation much reduced.

Asellus hoppinae Faxon

Localities.—ARKANSAS: JACKSON Co.: small, swift stream on hillside, 1.5 miles southwest of Olyphant. PULASKI Co.: small creek, 3 miles northeast of North Little Rock. JOHNSON Co.: small creek, west of the College Chapel, Clarksville; spring, near Lee's Tavern, 2 miles northeast of Clarksville; creek, King's Canyon, 5 miles north of Clarksville. LOGAN Co.: spring, on Shelf Road of Mt. Nebo, Mt. Nebo State Park.

This will undoubtedly prove to be a common species throughout northern Arkansas.

Mancasellus macrourus Garman

Localities.—ARKANSAS: LAWRENCE Co.: roadside slough, 2 miles southwest of Minturn. SCOTT Co.: creek, Y-City, 4 miles south of Boles. OKLAHOMA: MAYES Co.: Spring Creek, Locust Grove. OKFUSKEE Co.: Seeping Springs, near Scout camp at Okamah. SEMINOLE Co.: pond near Cromwell. PONTOTOC Co.: City Lake, (artificial, 25 years old), Ada; also in various small temporary tributaries of every creek in the county. JOHNSTON Co.: small creek, branch of Pennington River, Devil's Den Park, 4 miles north of Tishomingo; pond, 5 miles south of Connerville. WOODS Co.: small creek, near airport, Waynoka.

Mancasellus brachyurus Harger

Locality.—TENNESSEE: SEVIER Co.: small spring branch, halfway up the side of Blanket Mountain, Smoky Mountains National Park.

Mancasellus ouachitaensis sp. nov.

Description.—Large specimens may attain a length of 11 mm. The general appearance of this species is like that of *Mancasellus macrourus*, excepting that the uropoda are somewhat longer in proportion. The head may or may not be laterally incised.

Segments of the flagellum of the antennules number up to 8 or 9 in mature specimens, although some comparatively large specimens have no more than 5 or 6. The antennae may attain a length equal to that of the body and the flagellum may have as many as 90 segments.

The male gnathopoda are distinctive. There are 2 or 3 propodal processes (Fig. 13), the one of the medial region of the palm being always well devel-

oped, and the distal one small. The heavy spine at the base of the palm may be present or absent. However, the usual condition is shown in Fig. 13. The basal portion of the dactyl is thickened sometimes to form a process and may be much more definite than shown in the figure.

The armature of the dactyl of the last peraeopoda consists of 4 or 5 spines on the under side, increasing in size distally, and a row of 5 to 7 setae at the base of the dactyl on the opposite side. Generally also there are 1 or 2 setae at the base of the dactyl on the under side.

Fig. 18 shows the form of the first male pleopoda. Note that the basal segment is nearly as long and wide as the distal one. There are 1 or 2 coupling hooks. The setae of the distal segment are small terminally and increase in size onto the sides. There is a more or less abrupt transition between the short and long setae. The maximum number of the long setae is about 15, and 18 for the short ones, but the total may be much less.

Gross form of the second pleopoda of the male is shown in Fig. 20. The internal angle of the basal segment is finely serrate but lacks setae, and the exopodite has up to 18 setae on the distal segment. The details of the tip of the endopodite are shown in Fig. 17. These must be examined carefully to separate from *M. macrourus*. The hook at "A" seems to be characteristic of *M. ouachitaensis*. The shorter lobe at the tip is also more heavily spined and the process at "B" longer.

The uropoda are about $\frac{2}{3}$ of the length of the pleotelson, although in occasional specimens the uropoda may be as long as the pleotelson. The proportions of basal segment and endopodite to exopodite are shown in Fig. 15. The longer the uropoda the shorter the proportion of exopodite to endopodite. In the largest specimens the exopodite may not exceed $\frac{1}{2}$ the length of the endopodite.

This species, as already indicated, is much like *Mancasellus macrourus*, differing specifically from it in the armature of the propodus of the male gnathopoda. In *M. macrourus* the basal or proximal process is very large, much larger than the middle and distal processes, while in *M. ouachitaensis* this process is absent or at most represented by only a low, spine-tipped elevation.

The gnathopoda of *M. ouachitaensis* somewhat resemble those described for *M. lineatus* (Say). Say originally placed the species in *Asellus*, but the description, as pointed out by Richardson (1905) and Van Name (1936) seems to indicate *Mancasellus*. However, in *M. lineatus* the exopodite of the uropods is said to be $\frac{1}{3}$ as long as the endopodite, which is outside the variational range of *M. ouachitaensis*.

Cotypes.—U. S. National Museum, catalog number 74844; and collections of the authors.

Localities.—OKLAHOMA: LEFLORE CO.: tributary of Kiamichi River, near Big Cedar (Type locality). LATIMER CO.: tributaries of the Fourche Maline River, State Game Preserve, north of Wilburton. PUSHMATAHA CO.: tributaries of the Kiamichi River, near Tuskahoma.

Mancasellus louisianae sp. nov.

Description.—The body length in this species does not exceed 7.5 mm. in any of our specimens. The color is brown with yellow mottlings. The head is deeply incised and the incision may be narrow or very broad. The antennules have up to 7 flagellar segments, and the antennae 56 in the largest specimen. The antennae are not as long as the body by a considerable margin.

The dactyl of the male gnathopoda is slightly thickened at the base. The propodus has a large central process on the palmar margin, a small distal one, and a spine at the base, but no process. Other details of the armature are shown in Fig. 19. The dactyl of the last peraeopoda possesses up to 5 spines below, the last (accessory claw) large and curved. There is a row of 4 or 5 setae above.

In the first pleopoda of the male (Fig. 12), the basal segment is much narrower than the distal one, and there are 2 pairs of coupling hooks. The setae of the distal segment number up to 30. The second pleopoda of the male (Fig. 16) have the following characteristics: (1) the internal distal angle of the basal segment not at all cut away, so that this segment is practically square, (2) the exopodite is straight on the outer margin, hardly curving to the tip at all, (3) the setae number up to about 14, (4) the endopodite is without even a suggestion of apophysis at the base, (5) the copulatory or bulbar portion of the exopodite is nearly spherical in outline. Note also in Fig. 11 the form of the tip of this appendage.

The uropoda are shown in Fig. 14. They are slightly more than half the length of the pleotelson, and the endopodite is longer than the basal segment. The exopodite is nearly always about $\frac{2}{3}$ the length of the endopodite. Both rami are cylindrical or only slightly flattened.

Mancasellus louisianae is closely related to *Asellus hoppinae*, differing most definitely in the lack of mandibular palp in the former. *M. louisianae* also has relatively shorter uropods, and there are differences in detail of the armature of the gnathopods. It is quite evident that *Asellus hoppinae* does not belong in the genus *Asellus* in spite of the possession of a mandibular palp, a matter to be discussed in detail in a later paper.

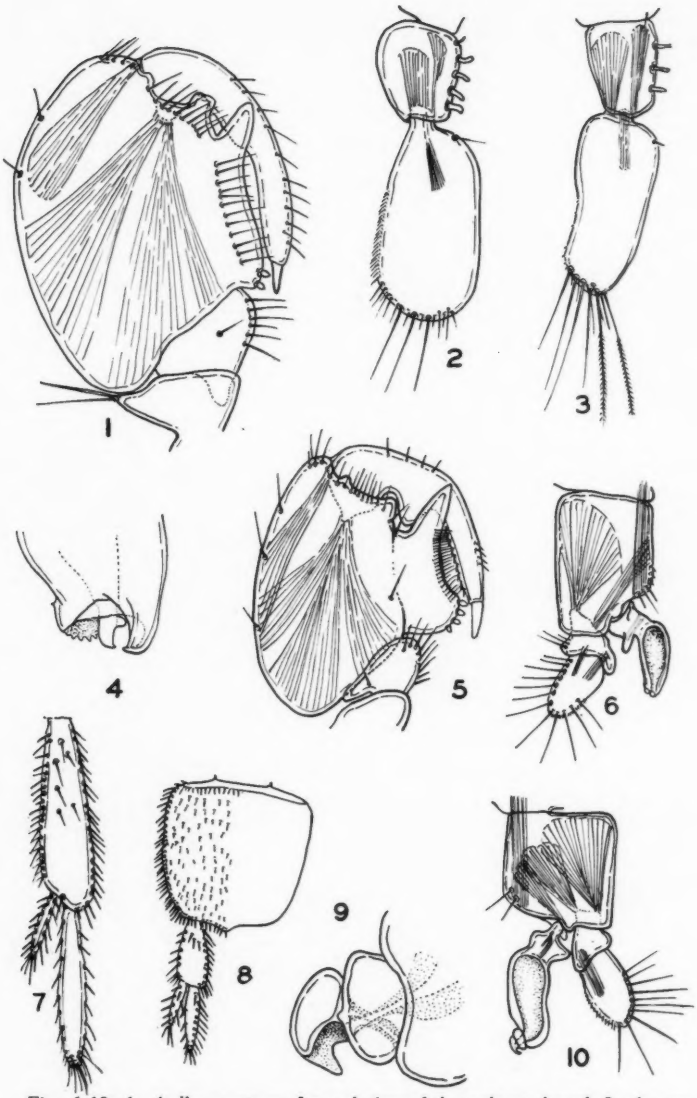
Cotypes.—U. S. National Museum, catalog number 74843; and collections of the authors.

Locality.—LOUISIANA: NATCHITOCHES PAR.: among dead leaves in a small creek below an artificial pond, property of Miss Caroline Dorman, 2 miles south of Saline (Type locality).

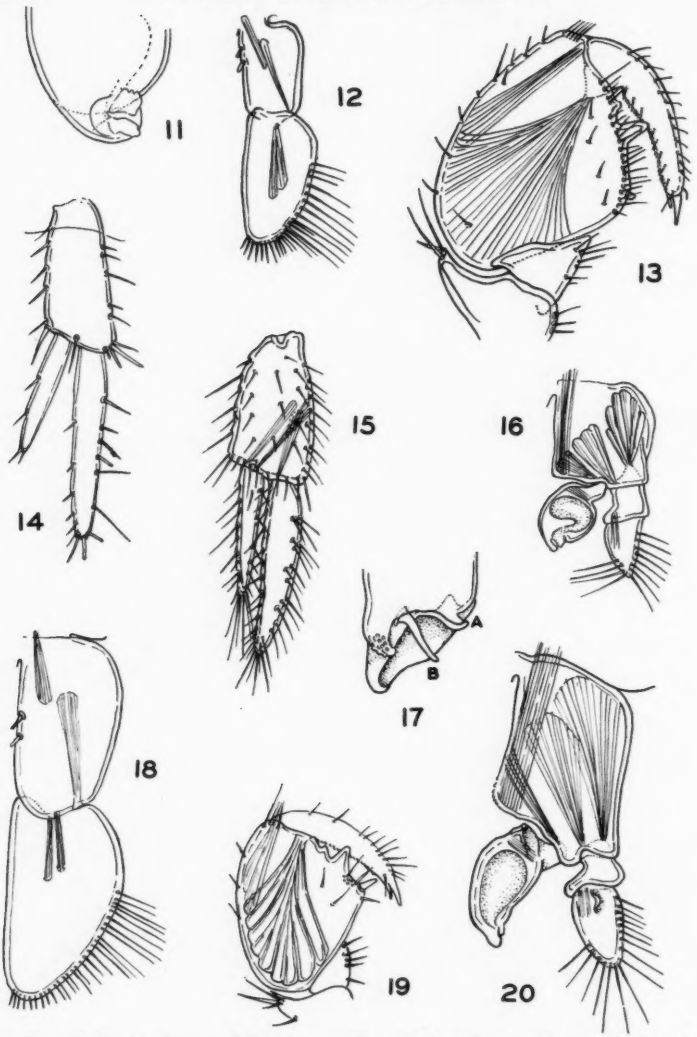
Family *Bopyridae*

Probopyrus bithynis Richardson

Locality.—MISSOURI: ST. LOUIS CO.: parasitic on *Macrobrachium ohionis* (Smith), Mississippi River, Hillcrest.



Figs. 1-10: 1, *Asellus montanus*. Internal view of the male gnathopod. 2. *A. montanus*. Male first pleopod. 3, *A. dentadactylus*. Male first pleopod. 4, *A. dentadactylus*. Tip of endopodite of male second pleopod. 5, *A. dentadactylus*. Internal view of male gnathopod. 6, *A. dentadactylus*. Male second pleopod. 7, *A. montanus*. Uropod of large male. 8, *A. dentadactylus*. Telson and uropod. 9, *A. montanus*. Tip of *endopodite* of male second pleopod. 10, *A. montanus*. Male second pleopod.



Figs. 11-20: 11, *Mancasellus louisianae*. Tip of endopodite of male second pleopod. 12, *M. louisianae*. Male first pleopod. 13, *M. ouachitaensis*. Male gnathopod. 14, *M. louisianae*. Uropod. 15, *M. ouachitaensis*. Uropod. 16, *M. louisianae*. Male second pleopod. 17, *M. ouachitaensis*. Tip of endopodite of male second pleopod. 18, *M. ouachitaensis*. Male first pleopod. 19, *M. louisianae*. Male gnathopod. 20, *M. ouachitaensis*. Male second pleopod.

REFERENCES

FAXON, WALTER. 1889—*In*, Garman, Samuel: Cave Animals from Southwestern Missouri. Bull. Mus. Comp. Zool. **17**(6):225-239.

FORBES, S. A. 1876—List of Illinois Crustacea, with Descriptions of New Species. Bull. Ill. State Lab. Nat. Hist. **1**:3-26.

GARMAN, H. 1890—A new Freshwater Crustacean. Bull. Essex Inst. **22**:28-30.

HARGER, O. 1874—On a New Genus of Asellidae. Amer. Jour. Sci. Arts **7**(3):601-602.

———1876—Description of *Mancasellus brachyurus*, a new Fresh-Water Isopod. Amer. Jour. Sci. Arts **11**(3):304-305.

RACOVITZA, E. G. 1919—Notes sur les Isopods 6. *Asellus communis* Say.—7. Pleopods I et II des Asellids; morphologie et development. Arch. Zool. Exper. Gen. **58**(4):79-115.

RICHARDSON, HARRIET. 1905—A Monograph of the Isopods of North America. Bull. U. S. Nat. Mus. **54**:1-727.

SAY, THOMAS. 1818—An Account of the Crustacea of the United States. Jour. Acad. Nat. Sci. Phila. **1**(2):393-401, 423-433.

SMITH, S. I. AND A. E. VERRILL. 1871—Notice of the Invertebrata dredged in Lake Superior in 1871, by the U. S. Lake Survey, under the Direction of Gen. C. B. Comstock. S. I. Smith, Naturalist. Amer. Jour. Sci. Arts **2**(3):448-454.

VAN NAME, W. G. 1936—The American Land and Fresh-Water Isopod Crustacea. Bull. Amer. Mus. Nat. Hist. **71**:1-535.

EAST CENTRAL STATE TEACHERS COLLEGE,
ADA, OKLAHOMA
AND
MISSOURI BOTANICAL GARDEN,
ST. LOUIS, MISSOURI.

Family Names in the Order Araneae[1]

B. J. Kaston

There seem to be considerable differences of opinion among araneologists concerning the use of family names. Which name is used appears to depend upon several factors. There is first of all the worker's interpretation of what constitutes the taxonomic group "family." Then there is the matter of selecting the genus, to the stem of the name of which *idae* is added. Further, there may arise a question as to whether a name which has been in use for some time should be changed because its original "type" genus has turned out to be a synonym of an older genus, or has a preoccupied name which must give way to a new one.

In the matter of what constitutes the taxonomic group "family" the student is referred to the works of Petrunkevitch (1923, 1928, 1933), wherein a critique of earlier concepts will also be found. The earliest comprehensive discussions of the question appear in the classical papers of Thorell (especially 1869-70, 1870-73), and an almost complete synopsis of the various systems of classification to the time of writing is given by Dahl (1904).

On the selection of a type genus for a family much has been written and the situation is admirably summarized by Melander (1929). Unfortunately, the International Rules of Zoological Nomenclature fail to designate how the type genus of a family is to be selected. There are those (but in my opinion very few araneologists) who would select the earliest named genus. Thus Thomisidae would give way to Misumenidae because *Misumena* Latreille 1804 antedates *Thomisus* Walckenaer 1805; but Oberholser (1920) has presented good objections to this arrangement. Others would consider as type genus that one from the name of which the family name was originally formed; thus *Thomisus* automatically became the type genus when Sundevall set up the family Thomisidae in 1833. This latter plan probably meets with the approval of the majority of workers. Confusion has resulted, however, on account of some investigators not always knowing just who was the first to propose a name for the family concerned. One is apt to be misled even by an author whom one supposes to be establishing a family name. For example, Bertkau proposed the name Sparassidae in 1872. For the same family Thorell proposed the name Heteropodidae in 1873. Since Bertkau's paper does not appear in the rather complete list of literature given by Thorell up to the time of writing his paper it is fair to assume that Thorell was unaware of Bertkau's establishing the new family. However, Simon, who in 1874 referred to Thorell's work did not accept the latter's name, Heteropodidae. Instead, he used the name Sparassidae as though it originated with him. In 1878 Bertkau went even farther and actually appended the word *mihi* to a number of family

1 The subject has recently been touched upon by Fox (1937, J. Washington Acad. Sci. **27**:461).

names, among which Dictynidae, Uloboridae, Agelenidae, and Scytodidae had been used by investigators before him!

Although Article 5 of the International Code states that the name of a family is to be changed when the name of its type genus is changed, there are some authors who prefer to consider such long standing names as, e.g., Attidae and Drassidae as *nomina conservanda* even though *Attus* and *Drassus* have been shown to be synonyms of *Salticus* and *Gnaphosa* respectively.

In Dahl's (1904) synopsis the family names are credited and dates given, but no bibliographic citations were made. However, in addition to some actual omissions, a number of the names are credited to the wrong authors and a few of the dates are in error so that priority cannot be correctly determined. The following list corrects that of Dahl's where necessary, brings it down to date insofar as family names are concerned, and gives in addition the exact bibliographic reference to the place where the name was first published. It includes all the names of which I have been able to learn, except those proposed for families having only fossil representatives. While, no doubt, errors of omission will later be discovered I have attempted to eliminate errors of commission by personally checking all dates, volume and page numbers, etc. The standard ending *idae* is used for all, but where the original orthography was different it is included in parentheses.

The names are arranged alphabetically, the 62 accepted by Petrunkevitch in his latest system being printed in bold face (e.g., **Drassidae**). Those, which according to the Rules of Nomenclature should be used instead of their synonyms accepted by Petrunkevitch, appear in large and small capitals (e.g., GNAPHOSIDAE). Italics indicate names based on groups having subfamily rank in the above mentioned system (e.g., *Tetragnathidae*). Those based on groups having less than subfamily rank are indicated in large and small capitals of smaller type (e.g., XYSTICIDAE). All others are considered as synonyms of one sort or another and appear in small italics (e.g., *Calommatidae*). While an approximate indication of their position in the system is given, the limits of the groups considered as families have, in many cases, varied widely, and no attempt is made to give exact modern equivalents of these names. It should be understood that a reference list is just that and not a revision.

Acanthoctenidae F. O. P.-Cambridge 1902, Biol. Centr. Americana, Arach. Aran., 2:354.

Actinopodidae Berland 1932, Les Arachnides, p. 324. Subfamily of Ctenizidae.

Agelenidae (Agelenides) C. L. Koch 1837, Uebers. d. Arachn.-Syst. Heft 1:13.

Amaurobiidae Bertkau 1878, Arch. f. Naturgeschichte 44:357.

In 1870 Thorell (On European Spiders, p. 118) referred to L. Koch having used this name in a family sense. However, I have been unable to find it in Koch's papers.

Ammoxenidae Simon 1893, Hist. Nat. Ar., 1:452.

AMYCIAEIDAE Dahl 1913, Vergl. Physiol. u. Morph. d. Spinnentiere, S. 18.
Amyciaea Simon is in the subfamily Dietinae of the Thomisidae.

Anyphaenidae Bertkau 1878, Arch. f. Naturgeschichte, 44:358.

Aphantochilidae (Aphantochiloidae) Thorell 1873, Rem. Syn. European Spiders, p. 606.

Araneidae Dahl 1912, Handwörterb. d. Naturw., 1. Aufl., 1: 502.
It would seem as though this name had been used in a family sense before 1912 but I have been unable to locate a reference. Generally considered approximately equivalent to Argiopidae minus Tetragnathinae.

Archaeidae C. L. Koch and Berendt 1854, Die im Bernstein befindlichen organischen Reste der Vorwelt. Bd. 1, Abt. 2:19.

ARCYIDAE (Arcyides) O. P.-Cambridge 1873, Zool. Record for 1871, 8: 205.
Arcys Walckenaer is in the subfamily Araneinae of the Argiopidae.

Argiopidae Simon 1890, Ann. Soc. Ent. France, sér. 6, 10:81.

Argyronetidae Menge 1871, Schr. d. Naturf. Ges. Danzig 2(4):293.

Attidae (Attides) Sundevall 1833, Consp. Arachn., p. 25.
Synonym of Salticidae; (*Attus* Walckenaer = *Salticus* Latreille).

Atypidae Bertkau 1878, Arch. f. Naturgeschichte 44:356.

Avicularüidae Simon 1873, Mém. Soc. Roy. Sci. Liège, sér. 2, 5(8):9.
Practically synonymous with Theraphosidae.

Barychelidae Pocock 1897, Proc. Zool. Soc. London, p. 725.

BOMIDAE Dahl 1913, Vergl. Physiol. u. Morph. d. Spinnentiere, S. 18.
Bomis L. Koch is in the subfamily Misumeninae of the Thomisidae.

Bradystichidae Simon 1884, Ann. Soc. Ent. Belgique, 28 (C.R.):ccxcvii.
Subfamily of Lycosidae.

BRUCHARACHNIDAE Mello-Leitão 1925, Physis (Buenos Aires), 8:233.
Brucharachnae Mello-Leitão is in the subfamily Gamasomorphinae of the Oonopidae.

Calommatidae (Calommatoidae) Thorell 1887, Ann. Mus. Civ. Stor. Nat. Genova, ser. 2, 5:8.
This name was substituted for Atypidae (Atypoidae) to avoid confusion with the almost identical genus name *Atypoides*.

Caponiidae Simon 1890, Ann. Soc. Ent. France, sér. 6, 10:81.

CELAENIDAE (Celaeniden) L. Koch 1872, Die Arachniden Australiens, S. 231.
Celaenia Thorell is in the subfamily Araneinae of the Argiopidae.

Chalinuridae (Chalinuroidae) Thorell 1873, Rem. Syn. European Spiders, p. 605.
Equals Hersiliidae.

Chersidae Canestrini and Pavesi 1869, Atti Soc. Italiana Sci. Nat., for 1868, 11:812.
Synonym of Palpimanidae; (*Chersis* Walckenaer = *Palpimanus* Dufour).

CHEIRACANTHIDAE (Cheirocantidae) Wagner 1888, Horae Soc. Ent. Rossicae 22:72.
Cheiracanthium C. L. Koch is in the subfamily Clubioninae of the Clubionidae.

Ciniflonidae Blackwall 1841, Trans. Linn. Soc. London 18:606.
Equivalent to Amaurobiidae + Dictynidae, plus perhaps other cribellate families.

Clubionidae Wagner 1888, Horae Soc. Ent. Rossicae 22:67.

Colophonidae (Colophonides) O. P.-Cambridge 1874, Ann. Mag. Nat. Hist., ser. 4, 14:170.
Synonym of Caponiidae; (*Colophon* O. P.-Cambridge preoc. = *Caponia* Simon).

Cryptothelidae (Cryptotheliden) L. Koch 1872, Die Arachniden Australiens, S. 238.
Subfamily of Zodariidae.

Ctenidae (Ctenoidae) Keyserling 1876, Verh. Zool.-Bot. Ges. Wien, 26:609.

Ctenizidae (Ctenizoidae) Thorell 1887, Ann. Mus. Civ. Stor. Nat. Genova, ser. 2, 5:8.

Ctenophoridae Blackwall 1870, Ann. Mag. Nat. Hist., ser. 4, 5:401.
Synonym of Mimetidae; (*Ctenophora* Blackwall = *Mimetus* Hentz).

CYCAIDAE (Cycaoidae) Thorell 1890, Ann. Mus. Civ. Stor. Nat. Genova, ser. 2, 8:344.
Cycais Thorell is in the subfamily Cybaeinae of the Agelenidae.

Dendryphantidae Menge 1878, Schr. d. Naturf. Ges. Danzig 4(3):6.
Subfamily of Attidae.

DIAEIDAE Dahl 1912, Handwörterb. d. Naturw., 1. Aufl., 1:506.
Diaea Thorell is in the subfamily Misumeninae of the Thomisidae.

Dictynidae (Dictynides) O. P.-Cambridge 1871, Zool. Record for 1870, 7:213.

Dinopidae (Deinopides) C. L. Koch 1850, Uebers. d. Arachn.-Syst., Heft 5:41.

Dipluridae Pocock 1897, Proc. Zool. Soc. London, p. 725.

Drassidae (Drassides) Sundevall 1833, Consp. Arachn., p. 17.
Synonym of Gnaphosidae; (*Drassus* Walckenaer = *Gnaphosa* Latreille).

Dysderidae (Dysderides) C. L. Koch 1837, Uebers. d. Arachn.-Syst., Heft 1:20.

Enyoidae Thorell 1869, Nova Acta Reg. Soc. Sci. Upsaliensis, ser. 3, 7:42.
Synonym of Zodariidae; (*Enyo* Audouin preoc. = *Zodarion* Walckenaer).

Epeiridae (Epeirides) Sundevall 1833, Consp. Arachn., p. 13.
Generally considered equivalent to Argiopidae, or to Argiopidae minus Tetragnathinae.

EPSINIDAE (Episinides) O. P.-Cambridge 1879, Proc. Zool. Soc. London, p. 701.
Episinus Latreille is in the subfamily Theridiinae of the Theridiidae.

Eresidae (Eresides) C. L. Koch 1850, Uebers. d. Arachn.-Syst., Heft 5:70.

Erigonidae Gerhardt 1923, Arch. f. Naturgeschichte, Abt. A, 87, (4):123.
Synonym of Micryphantidae.

Eriodontidae C. L. Koch and Berendt 1854, Die im Bernstein befindlichen organischen Reste der Vorwelt. Bd. 1, Abt. 2: 69.
Eriodon Latreille = *Missulena* Walckenaer, which is in the subfamily Actinopodinae of the Ctenizidae.

ERIPIDAE (Eripides) O. P.-Cambridge 1877, Proc. Zool. Soc. London, p. 558.
Eripus Walckenaer preoc. = *Epicadus* Simon, which is in the subfamily Stephanopsinae of the Thomisidae.

Euetriidae (Euetrioidae) Thorell 1887, Ann. Mus. Civ. Stor. Nat. Genova, ser. 2, 5:8.
This name was substituted for Epeiridae (Epeiroidae) to avoid confusion with the almost identical genus name *Epeiroides*.

Filistatidae Ausserer 1867, Verh. Zool.-Bot. Ges. Wien 17:140.

Gasteracanthidae (Gasteracanthides) O. P.-Cambridge 1871, Zool. Record for 1870, 7:217.
Subfamily of Argiopidae.

GNAPHOSIDAE Pocock 1898, Ann. Mag. Nat. Hist., ser. 7, 2:219.
Name proposed to take the place of Drassidae (q.v.)

Hadrotarsidae (Hadrotarsoidae) Thorell 1881, Ann. Mus. Civ. Stor. Nat. Genova, 17:190.

Hahniidae Bertkau 1878, Arch. f. Naturgeschichte 44:358.

HAMATALIVIDAE Marx 1890, Proc. U. S. Nat. Mus. 12:592.
Hamataliva Keyserling is in the subfamily Oxyopinae of the Oxyopidae.

Hersiliidae (Hersilioidae) Thorell 1869, Nova Acta Reg. Soc. Sci. Upsaliensis, ser. 3, 7:42.

Heteropodidae (Heteropodoidae) Thorell 1873, Rem. Syn. European Spiders, p. 606.
Synonym of Sparassidae.

Homalonychidae Petrunkevitch 1923, Ann. New York Acad. Sci. 29:162.

Hypochilidae Marx 1888, Entom. Americana 4:161.

KATADYSIDAE (Catadysoidae) Thorell 1869, Nova Acta Reg. Soc. Sci. Upsaliensis, ser. 3, 7:43.

This family was erected on the basis of characters ascribed by Hentz to his genus *Katadysas*. These characters were later shown to be non-existent and the genus to be a synonym of *Zora* C. L. Koch.

Leptonetidae Simon 1890, Ann. Soc. Ent. France, sér. 6, 10:80.

Linyphiidae Blackwall 1859, Ann. Mag. Nat. Hist., ser. 3, 4:261.

Liphistiidae (Liphistioidae) Thorell 1869, Nova Acta Reg. Soc. Sci. Upsaliensis, ser. 3, 7:43.

Lycosidae (Lycosides) Sundevall 1833, Consp. Arachn., p. 23.

Lyssomanidae Banks 1892, Canadian Ent. 24:90.

MECICOBOTHRIIDAE (Mecicobothrioidae) Holmberg 1882, Bol. Acad. Nac. Cienc. Córdoba (Argentina) 4:153.
Mecicobothrium Holmberg is in the subfamily Hexurinae of the Dipluridae.

Miagrammopidae (Miagrammopides) O. P.-Cambridge 1871, Zool. Record for 1870, 7:218.
Subfamily of Uloboridae.

Micariidae Brown 1898, Zool. Record for 1897, 34 (Arachn.):36.
Subfamily of Clubionidae.

Micryphantidae (Micryphantides) Bertkau 1872, Arch. f. Naturgeschichte 38:232.

Migidae Pocock 1897, Proc. Zool. Soc. London, p. 725.

Miltiidae (Miltioidae) Thorell 1873, Rem. Syn. European Spiders, p. 602.
Synonym of Prodidomidae; (*Miltia* Simon = *Prodidomus* Hentz).

Mimetidae Simon 1890, Ann. Soc. Ent. France, sér. 6, 10:81.

Misumenidae (Misumenoidae) Thorell 1887, Ann. Mus. Civ. Stor. Nat. Genova, ser. 2, 5:8.
This name was substituted for Thomisidae (Thomisoidae) to avoid confusion with the almost identical genus name *Thomisoides*.

Mithraidae (Mithraides) C. L. Koch 1850, Uebers. d. Arachn.-Syst., Heft 5:15.
Mithras C. L. Koch = *Hyptiotes* Walckenaer, which is in the subfamily Hyptiotinae of the Uloboridae.

Mygalidae (Mygalides) Sundevall 1833, Consp. Arachn., p. 28.
Has probably been considered equivalent to Theraphosidae as a whole; though *Mygale* Walckenaer preoc. = *Poecilotheria* Simon, which is in the subfamily Selenocosmiinae.

Myrmecidae (Myrmeoides) C. L. Koch 1850, Uebers. d. Arachn.-Syst., Heft 5:41.
Apparently included genera from the Corinninae and Micariinae of the Clubionidae.

Nesticidae Dahl 1926, Spinnentiere I, Tierwelt Deutschlands Teil 3:17.
Subfamily of Theridiidae.

Ochyroceratidae Fage 1912, Arch. Zool. Exp. et Gén., sér. 5, 10:97.
Subfamily of Leptonetidae.

Oecobiidae Blackwall 1862, Ann. Mag. Nat. Hist., ser. 3, 9:382.

Omanidae (Omanoidae) Thorell 1869, Nova Acta Reg. Soc. Sci. Upsaliensis, ser. 3, 7:44.
Synonym of Oecobiidae; (*Omanus* Thorell = *Oecobius* Lucas).

Oonopidae Simon 1890, Ann. Soc. Ent. France, sér. 6, 10:80.

Ornithoctonidae Pocock 1895, Ann. Mag. Nat. Hist., ser. 6, 15:167.
Subfamily of Theraphosidae.

OTIOTHOPIDAE (Otiothopoidae) Thorell 1869, Nova Acta Reg. Soc. Sci. Upsaliensis, ser. 3, 7:43.
Otiothops MacLeay is in the subfamily Palpimaninae of the Palpimanidae.

Oxyopidae (Oxyopoidae) Thorell 1869, Nova Acta Reg. Soc. Sci. Upsaliensis, ser. 3, 7:42.

PACHYGNATHIDAE Menge 1866, Schr. d. Naturf. Ges. Danzig 2(1):94.
Pachygnatha Sundevall is in the subfamily Tetragnathinae of the Argiopidae.

Palpimanidae O. P.-Cambridge 1871, Zool. Record for 1870, 7:214.

Paratropididae Mello-Leitão 1923, Revista do Museu Paulista 13:32.

Perissoblemmatidae O. P.-Cambridge 1882, Zool. Record for 1881, 18 (Arachn.):17.
Perissoblemma O. P.-Cambridge = Trechalea Thorell which is in the subfamily Thaumasiinae of the Pisauridae.

Phaedimidae (Phaedimoidae) Thorell 1889, Ann. Mus. Civ. Stor. Nat. Genova, ser. 2, 8:304.
Phaedima Thorell preoc. = *Paculla* Simon which is in the subfamily Pacullinae of the Theridiidae.

Philodromidae (Philodromides) O. P.-Cambridge 1871, Zool. Record for 1870, 7:220.
Subfamily of Thomisidae.

Pholcidae (Pholcides) C. L. Koch 1850, Uebers. d. Arachn.-Syst., Heft 5:31.

Phoroncididae (Phoroncidides) O. P.-Cambridge 1875, Zool. Record for 1873, 10:206.
Subfamily of Theridiidae.

Phycidae (Phycoidae) Thorell 1873, Rem. Syn. European Spiders, p. 600.
Phycus O. P.-Cambridge preoc. — *Phylarchus* Simon, which is in the subfamily Theridiinae of the Theridiidae.

Pisauridae Simon 1890, Ann. Soc. Ent. France, sér. 6, 10:82.

Platoridae Simon 1890, Ann. Soc. Ent. France, sér. 6, 10:82.

PLATYTHOMISIDAE Dahl 1913, Vergl. Physiol. u. Morph. d. Spinnentiere, S. 17.
Platythomisus Doleschall is in the subfamily Misumeninae of the Thomisidae.

Podophthalmidae (Podophthalmides) O. P.-Cambridge 1873, Proc. Zool. Soc. London, p. 118.
Podophthalma Capello preoc. = *Euprosthenops* Pocock, which is in the subfamily Pisaurinae of the Pisauridae.

POLTIDAE (Poltides) O. P.-Cambridge 1878, Zool. Record for 1876, 13 (Arachn.):9.
Poltys C. L. Koch is in the subfamily Araneinae of the Argiopidae.

Prodidomidae Marx 1890, Proc. U.S. Nat. Mus. 12:518.

Psechridae Simon 1890, Ann. Soc. Ent. France, sér. 6, 10:80.

Pycnothelidae Petrunkevitch 1923, Ann. New York Acad. Sci. 29:154.

RHIOIDAE Thorell 1873, Rem. Syn. European Spiders, p. 603.
Rhion O. P.-Cambridge is in the subfamily Dictyninae of the Dictynidae.

SALTICIDAE Blackwall 1841, Trans. Linn. Soc. London 18:616.
Synonym of Attidae; but *Attus* Walckenaen = *Salticus* Latreille.

Scytodidae Blackwall 1852, Ann. Mag. Nat. Hist., ser. 2, 10:253.
Synonym of Sicariidae. It is not clear to me why Scytodidae should not be used, rather than Sicariidae. The latter seems to be preferred by many, perhaps influenced by the fact that it was proposed by Simon.

Segestriidae Petrunkevitch 1933, Trans. Connecticut Acad. Sci. 31:330.

Selenocosmiidae Pocock 1895, Ann. Mag. Nat. Hist., ser. 6, 15:167.
Subfamily of Theraphosidae.

Selenopidae F. O. P.-Cambridge 1900, Biol. Centr. Americana, Arachn. Aran., 2:115.

Senoculidae Simon 1890, Ann. Soc. Ent. France, sér. 6, 10:82.

Sicariidae Simon 1890, Ann. Soc. Ent. France, sér. 6, 10:81.
Synonym of Scytodidae (q.v.).

Sparassidae (Sparassides) Bertkau 1872, Arch. f. Naturgeschichte 38:232.

Sphasidae (Sphasides) O. P.-Cambridge 1871, Zool. Record for 1870, 7:220.
Synonym of Oxyopidae; (*Sphasus* Walckenaer = *Oxyopes* Latreille).

Stenochilidae (Stenochiloidae) Thorell 1873, Rem. Syn. European Spiders, p. 603.
Subfamily of Palpimanidae.

Stephanopsidae (Stephanopides) O. P.-Cambridge 1871, Zool. Record for 1870, 7:219.
Subfamily of Thomisidae.

Strophiidae Dahl 1913, Vergl. Physiol. u. Morph. d. Spinnentiere, S. 16.
Subfamily of Thomisidae.

Symphytognathidae Hickman 1931, Proc. Zool. Soc. London, p. 1321.

Telemidae Petrunkevitch 1923, Ann. New York Acad. Sci. 29:160.

Tengellidae Dahl 1908, Abh. K. Leop.-Carol. Akad. Naturf. 88:194.

TETRABLEMMIDAE (Tetrablemmides) O. P.-Cambridge 1873, Proc. Zool. Soc. London, p. 114.
Tetrablemma O. P.-Cambridge is in the subfamily Gamasomorphinae of the Oonopidae.

Tetragnathidae Menge 1866, Schr. d. Naturf. Ges. Danzig 2(1):90.
Subfamily of Argiopidae.

Theraphosidae (Theraphosoidae) Thorell 1869, Nova Acta Reg. Soc. Sci. Upsaliensis, ser. 3, 7:42.

Theridiidae (Theridiides) Sundevall 1833, Consp. Arachn., p. 15.

Thlaosomidae (Thlaosomoides) Thorell 1873 (April 21), Rem. Syn. European Spiders, p. 600.
Also (Thlaosomatides) O. P.-Cambridge 1873 (May), Zool. Record for 1871, 8:204.
Thlaosoma O. P.-Cambridge = *Celaenia* Thorell which is in the subfamily Araneinae of the Argiopidae.

Thomisidae (Thomisides) Sundevall 1833, Consp. Arachn., p. 27.

TRECHALIDAE (Trechaelidae) Brown 1898, Zool. Record for 1897, 34 (Arachn.):41.
Trechalea Thorell is in the subfamily Thaumasiinae of the Pisauridae.

Triclaridae (Triclarides) O. P.-Cambridge 1877, Proc. Zool. Soc. London, p. 567.
Triclaria C. L. Koch preoc. = *Trechalea* Thorell, which is in the subfamily Thaumasiinae of the Pisauridae.

TROCHANTERIDAE (Trochanteroidae) Karsch 1879, Ztschr. Ges. Naturw. [for 1878], ser. 3, 3:817.
Trochanteria Karsch is in the subfamily Drassodinae of the Drassidae.

Uloboridae (Uloborides) O. P.-Cambridge 1871, Zool. Record for 1870, 7:218.

URARACHINIDAE Dahl 1913, Vergl. Physiol. u. Morph. d. Spinnentiere, S. 18.
Uraarachne Keyserling is in the subfamily Misumeninae of the Thomisidae.

Urocteidae (Urocteoidae) Thorell 1869, Nova Acta Reg. Soc. Sci. Upsaliensis, ser. 3, 7:42.

XYSTICIDAE Dahl 1912, Handwörterb. d. Naturw., 1. Aufl., 1: 506.
Xysticus C. L. Koch is in the subfamily Misumeninae of the Thomisidae.

Zimiridae (Zimiroidae) Thorell 1890, Ann. Mus. Civ. Stor. Nat. Genova, ser. 2, 8:383.
Subfamily of Prodidomidae.

Zodariidae (Zodarioidae) Thorell 1881, Ann. Mus. Civ. Stor. Nat. Genova 17:184.

ZORIDAE DAHL 1912, Handwörterb. d. Naturw., 1. Aufl., 1:506.
Zora C. L. Koch is in the subfamily Acantheinae of the Ctenidae.

ZOROCRATIDAE Dahl 1913, Vergl. Physiol. u. Morph. d. Spinnentiere, S. 21.
Zorocrates Simon is in the subfamily Zoropsinae of the Zoropsidae.

Zoropsidae (Zoropsididae) Bertkau 1882, Arch. f. Naturgeschichte 48:337.

Note. The following has just recently come to my attention:

ANAPIDAE Kratochvil 1935. Acta Soc. Sci. Nat. Moravicae (Brno) **9**(12):17.
Anapis Simon is in the subfamily Pholcommatinae of the Theridiidae.

REFERENCES

DAHL, F. 1904—Ueber das System der Spinnen *(Araneae)*. Sitz.-Ber. Ges. naturf. Freunde Berlin **1904**:93-120.

MELANDER, A. L. 1929—The selection of family names. Trans. 4th Intern. Cong. Ent., Ithaca, N. Y., (1928), **2**:657-664.

OBERHOLSER, H. 1920—The nomenclature of families and subfamilies in zoology. Science, N. S., **52**:142-147.

PETRUNKEVITCH, A. 1923—On families of spiders. Ann. New York Acad. Sci. **29**:145-180.

———1928—Systema Aranearum. Trans. Connecticut Acad. Sci. **29**:1-270.

———1933—An inquiry into the natural classification of spiders based on a study of their internal anatomy. Trans. Connecticut Acad. Sci. **31**:299-389.

THORELL, T. 1869-1870—On European spiders. Nova Acta Reg. Soc. Sci. Upsaliensis, ser. 3, **7**:1-242.

———1870-1873—Remarks on synonyms of European spiders. Upsala. pp. 1-645.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION,
NEW HAVEN, CONN.

New Moss-Mites, Chiefly Midwestern—III

Arthur Paul Jacot

This paper is in large part based on material from decaying logs from Carlé Woods, Evanston, Illinois, collected by Mrs. Elizabeth T. Smith. The types of this material will be deposited with the Zoölogy Department of Northwestern University. Types the numbers of which bear an F, are to be deposited at the National Museum, others at the Museum of Comparative Zoölogy.

Parhypochthonius aphidinus octofilamentis subsp. nov.

Fig. 1

Differs from the species in having the bristles of posteroventral part of notogaster much longer (compare 11, p. 428, fig. 4A with my figure 1); bristles c1 (F1 of Grandjean) bent forward; bristles c2 and d2 (w and y of Grandjean) sharply bent; bristles b4 inserted much further forward. No asymmetry of the pseudostigmatic organs is apparent in the three specimens before me, taken from the same log. However, they are mounted on their sides. In all three the filaments of the organs of both sides are directed upward. Each organ bears eight filaments. Total length (including mandibles) 0.47 mm., length of posterior segment of abdomen 0.2 mm.

Holotype: from log from Carlé Woods, Evanston, Ill.; taken October 16th 1936, slide 9184. Paratypes: from same log, slides 9183 and 9185.

An important phylogenic characteristic apparent in this genus, seems to have been overlooked. In lateral aspect (figure 1) there is a strong constriction immediately behind the insertion of the interlamellar bristles and pseudostigmata. It is directed forward below the pseudostigmata so as to pass between them and the exopseudostigmatic bristles (figure 1). This seems to indicate that the exopseudostigmatic bristles are inserted on the prothorax, and not on the cephalon. In no other genus known to me is the prothorax so clearly demarked from the cephalon.

Figure 1 shows how the *a* row of notogastral bristles is inserted on anterior edge of the sclerotized notogaster, while the body wall which extends anteriad thereof (seen as a broad continuation of notogaster in well expanded specimens) is merely a thin flexible skin capable of considerable detraction and folding when the animal pulls back its "head."

The major bristle of the dorsal face of tibiae I is a long, nearly straight, stout spine reaching as far forward as insertions of the dorsodistal pair of bristles.

The pseudostigmatic organs of specimens from western North Carolina have six to seven filaments.

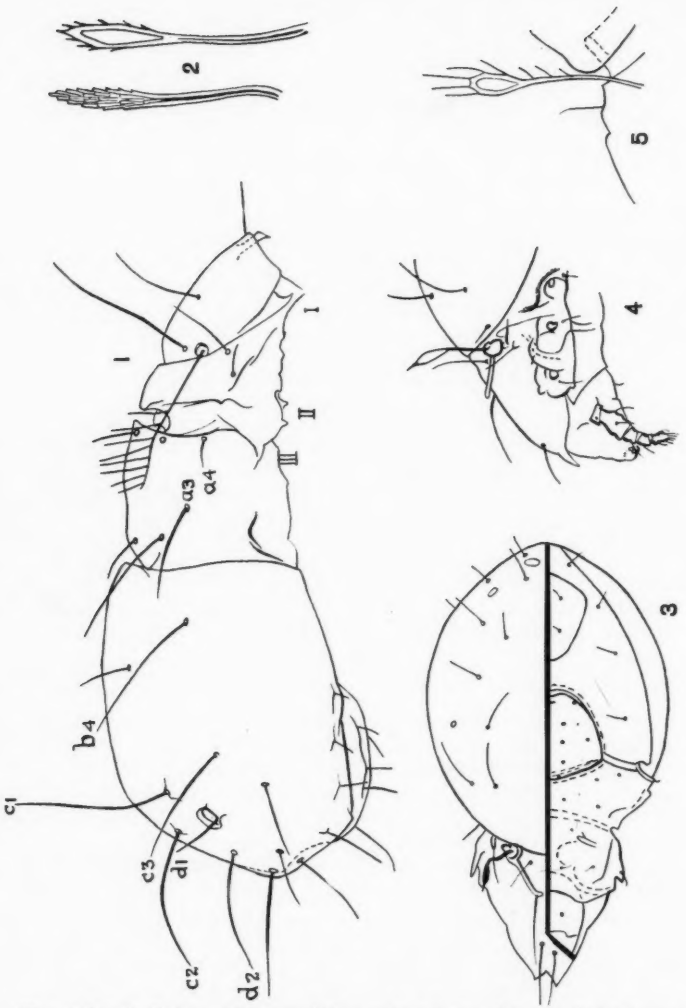


Plate 1, Fig. 1. *Parhypochthonius aphidinus octopectinatus* subsp. nov. Lateral aspect, mouth parts, legs, and bristle a2 omitted; ratio x200. Fig. 2. *Hermanniella subnigra rigida* subsp. nov. Pseudostigmatic organ to right of numeral. That to left of numeral is that of *Hermanniella subnigra seacea* (13, p. 238). Fig. 3. *Oribella lanceolata bifurcata* subsp. nov. Dorso/ventral aspects, mouth parts and legs omitted; ratio x200. Fig. 4. Lateral aspects of cephaloprothorax, legs omitted; ratio x200. Fig. 5. *Oppia carolinae barbatis* subsp. nov. Lateral aspect of posterior part of cephaloprothorax and anterior part of notogaster to show nature of corrugation; and of pseudostigmatic organ; ratio x440.

Hypochthonius luteus 19, p. 24, pl. 16, figs. 16-19; 20, p. 21.

One specimen from rotting husk of hickory nut, Chillicothe, Ohio; taken May 7th 1923, by August E. Miller, slide 122 (Miller Coll.).

Hermanniella subnigra rigida subsp. nov.

Fig. 2

Differs from *H.s.setacea* (13, p. 238) in that interlamellar and notogastral bristles tend to be straighter, that is, gently curved instead of bent; pseudostigmatic organs shorter, about the length of the interlamellar bristles, the head broader, distinctly eyed and less fimbriate (figure 2, right side of numeral. Left side is that of *H.s.setacea).*

Holotype: From leaf in Carlé Woods, Evanston, Ill.; taken November 2nd 1935, slide L86. Paratype: same but slide L84.

Oribella lanceolata bifurcata subsp. nov.

Figs. 3 and 4

Differs from the species (15, p. 394; 17, p. 398, pl. 32, figs. 12-15) in that rostrum is medially notched to form two prominent cusps which may be unequal (figure 3) and which *may* correspondingly offset the rostral bristles so that one bristle may be inserted more anteriad than the other; and that mouth parts project beyond rostrum more than is usual in the higher Oribatidae (figure 4). In the species the rostrum is pinched at sides to form one well defined cusp and the mouth parts are completely covered. Size: total length 0.3 to 0.33 mm., breadth 0.16 to 0.19 mm.

Notaspis castanea Hermann, of course, is not this species.

Holotype: from log, Carlé Woods, Evanston, Ill.; taken November 16th 1935, slide S21. Paratypes: from same log, slides S22, S23 (figured), S25, S28, 1449 (figured), 1450.

Oppia carolinae sp. nov.

Figs. 6 to 9

Notogaster complete, uninterrupted, smooth, bearing twenty-four bristles (figure 6); cephaloprothorax fairly smooth, except for granulations above tectopedia: lamellae (barely) discernible at distal end only; rostral bristles stout, few-barbed, strongly curved; rostrum thinly sclerotized distad of bristles (figure 9); lamellar bristles fine, inserted near center of cephaloprothorax; interlamellar bristles stout, inserted far from pseudostigmata; pseudostigmatic organs clavate, head compressed, with seven progressively longer filaments, four of which are longer than head, one of them quite long (figures 6-8); tectopedia I fairly well developed; tectopedia II not developed; tectopedia IV small with triangular point; bristles ad3 near lateral edge of ventral plate; apertures and ventral plate bristles as in figure 6; total length 0.27 mm., breadth 0.15 mm.

Cotypes: Twenty-seven specimens from litter of eighty year old-field stand behind laboratory buildings, Bent Creek Exp. Forest, Buncombe Co., N.Car.; taken September 13th, slide 34F3.2-12.

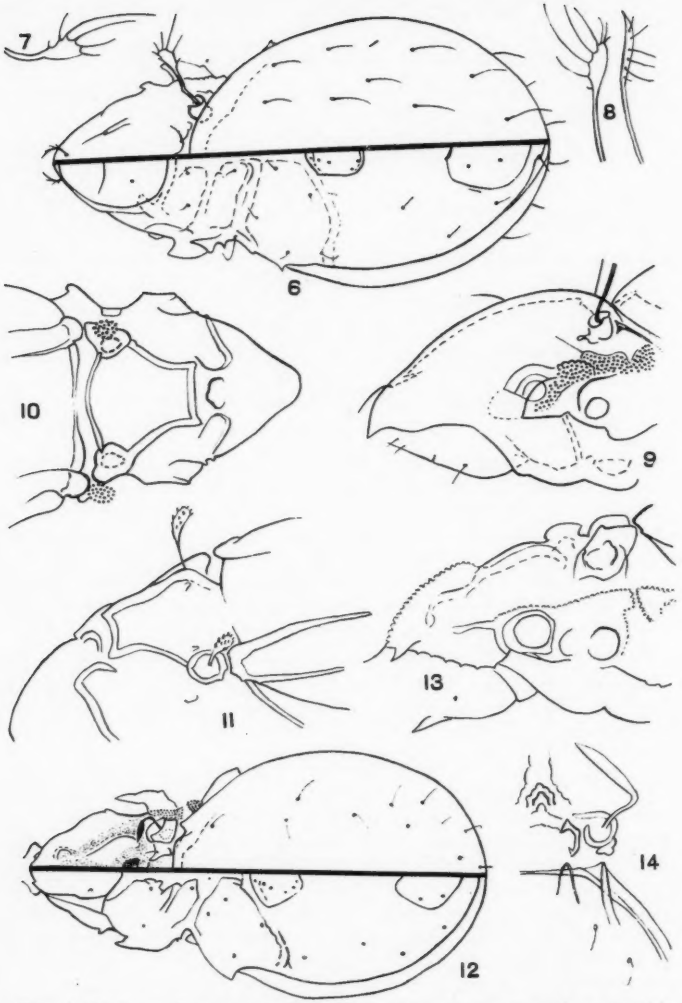


Plate 2. *Oppia carolinae* sp. nov. Fig. 6. Dorso/ventral aspects, mouth parts and legs omitted; ratio x264. Fig. 7. Pseudostigmatic organ head, full face; ratio x440. Fig. 8. Same, edge view and oblique view; ratio x440. Fig. 9. Cephaloprothorax, lateral aspect, mouth parts and legs omitted; ratio x330. *Oppia quadricarinata illinoisensis* subsp. nov. Fig. 10. Cephaloprothorax and anterior part of notogaster, dorsal aspect; ratio x440, Fig. 11. Cephaloprothorax and anterior part of notogaster; dorso-lateral aspect; ratio x 440. *Suctobelbila elizabethae* sp. nov. Fig. 12. Dorso/ventral aspects, mouth parts and legs omitted; ratio x264. Fig. 13. Cephaloprothorax, lateral aspect, mouth parts and legs omitted; ratio x440. Fig. 14. *Suctobelbella laevis* sp. nov. Dorsal aspect of pseudostigmatic organ, lamellar knob, interlamellar crest, and anterior edge of notogaster; ratio x440.

This species is closely related to *Dameosoma fasciatum* 21, p. 46, pl. 3, fig. 7, from the neighborhood of Florence, Italy. It differs in the stout interlamellar bristles, the long pseudostigmatic organ head filaments and the arrangement of the notogastral bristles.

Oppia furcata 23, p. 1, figs. 1, 2, is closely related. There is no bristle on collar of notogaster (behind pseudostigmata) in the American species but there is a pseudofissure further laterad and on longitudinal plane of bristles a2.

Oppia carolinae barbatis subsp. nov.

Fig. 5

Differs from the species in that area between pseudostigmata (as seen in lateral aspect) appears irregularly corrugated (figure 5); pedicel of pseudostigmatic organs with two or three short but conspicuous filaments, the filaments of the head much shorter than in the species (figure 5).

Holotype: from decaying log, Carlé Woods, Evanston, Ill.; taken April 18th 1936, slide 1237. Paratypes from same log, slides 1229, 1228.

Oppia minus simplissimus subsp. nov.

Differs from the species (21, p. 48, pl. 3, fig. 11) in having no sculpturing between pseudostigmata; pseudostigmatic organ head ovate in dorsal aspect, its distal end with three or four short cilia.

In this species shape of abdomen, as seen in dorsal aspect, varies with angle of vision from oval to obovate. It is one of the smallest well sclerotized Oribatids.

Holotype: from log from Carlé Woods, Evanston, Ill.; taken January 24th 1937, slide 5230. Paratype: from same log, slide 5229.

Oppia quadricarinata illinoisensis subsp. nov.

Figs. 10 and 11

Differs from the species (16, p. 393, pl. 7; 17, p. 385, pl. 31, figs. 13-15) in having simple, slender lamellae and translamella (figures 10, 11); no ridges or sculpturing within their compass; longer cephalon so that area between translamella and tip of rostrum is much greater (figure 10); ridge across genae much more anteriorly situated, the mesal end curving back to form a loop distad of ends of lamellae, thus forming a conspicuous pattern in dorsal aspect (figure 10); space between the loops of the genal ridges occupied by a weakly developed semicircular ridge. (Comparison based on Regensburg specimens). There is a great deal of variation in size in this species. It is one of the smallest heavily sclerotized Oribatids.

Holotype: from decaying log, Carlé Woods, Evanston, Ill.; taken April 18th 1936, slide 1230. Paratype: from same log, slide 1239. Lateral aspect from another log, slide 1302.

Suctobelbini trib. nov.

Minute Oribatidae with attenuate mouth parts, and narrow camerostome;

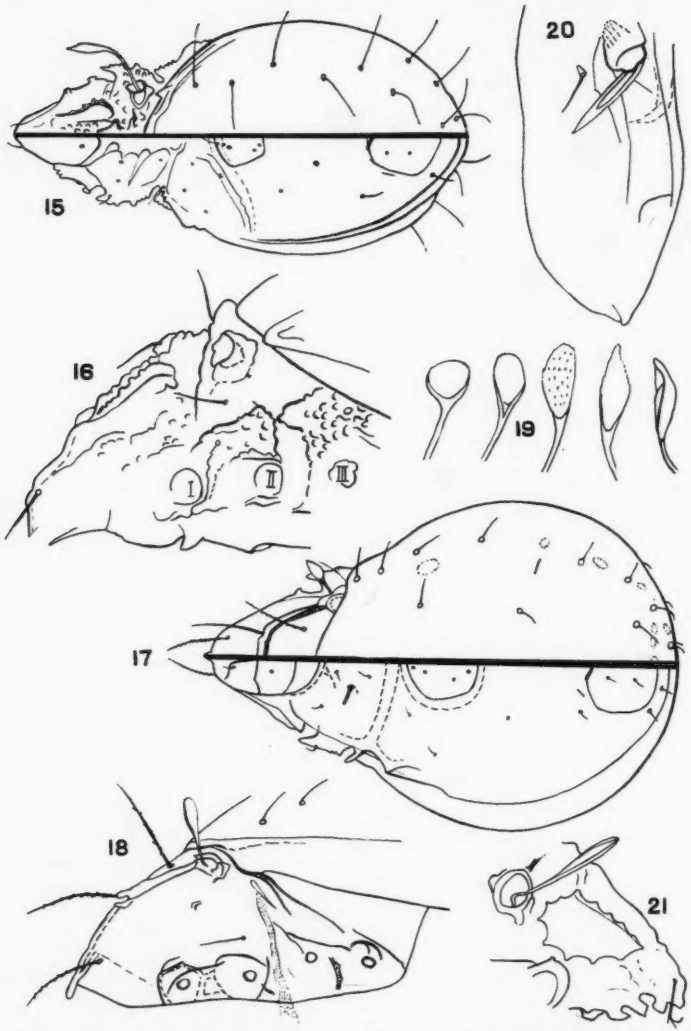


Plate 3. *Suctobelbila spicata* sp. nov. Fig. 15. Dorso/ventral aspects, mouth parts and legs omitted; ratio x220. Fig. 16. Lateral aspect of cephaloprothorax, mouth parts, legs and pseudostigmatic organs omitted; ratio x330. *Zygoribatula rostrata* sp. nov. Fig. 17. Dorso/ventral aspects of a female, mouth parts and legs omitted; ratio x150. Fig. 18. Lateral aspect, mouth parts and legs omitted; ratio x200. Fig. 19. Pseudostigmatic organs, dorsal aspect to left of numeral, lateral aspect to right; ratio x440. Fig. 20. *Phthiracarus luridus* (8, p. 417) (?) Lateral aspect of aspis and pseudostigmatic organ; ratio x200. Fig. 21. *Suctobelbella laevis* sp. nov. Lateral aspect of aspis and pseudostigmatic organ; ratio x440.

lamellae usually represented by more or less of a knob; genital and anal apertures distant.

Type: *Suctobelba* 21, p. 72.

Suctobelba grandis 21, p. 78.

A specimen from Urbana, Illinois; taken July 25th 1933 by Orlando Park has the notogastral bristles as in the original figure except that there is another pair anteriad of the posterior pair.

Suctobelbila elizabethae sp. nov.

Figs. 12 and 13

Bristles very fine, cephaloprothoracic not discernible except rostral; notogastral bristles disposed as in figure 12; anterior edge of notogaster angularly produced to form a nearly straight line; interlamellar bosses broad, high (figure 13), leaving a wide gap between them; lamellar knob semicircular, prominent (figure 12), high (figure 13); most of cephaloprothorax, including the entire rostral area very finely granular (figure 12); pseudostigmatic organs recurved so as to be held over cephaloprothorax, distal end directed mesad, head lanceolate, slender, pointed (figure 12); parathoracic bosses well developed, truncate (figures 12, 13), completely covered with the fine granulations; edge of rostrum produced as a fairly prominent cusp (figures 12, 13); edge of camerostome with about six denticles; anal cover bristles unusually lateral, adanal bristles also quite lateral; paramesal bristles extremely lateral; size small: length 0.22 to 0.25 mm., breadth 0.12 to 0.137 mm.

Holotype: from log 13, Carlé Woods, Evanston, Ill.; taken April 18th 1936, slide 1232. Paratypes from same log, slides 1224, 1227, 1231, 1233, 1235, 1236, 1238, 1240, 1241.

The position of notogastral bristle a2 is unusually far posteriad for the Suctobelbini.

One female has one large egg in one side.

Named after Mrs. Elizabeth Teter Smith, pioneer explorer of the Acarina of the old log.

Suctobelbila spicata sp. nov.

Figs. 15 and 16

Notogaster with rather long, stout, blunt bristles, the anterior four of which have lined up almost in a longitudinal row, each directed alternately to one side or the other (figure 15); pseudostigmatic organs outspread, with long pedicel and lanceolate head, the distal end sharply pointed (figure 15); rostral bristles fine, smooth; lamellar bristles fairly long, springing from an insignificant, colorless, Y-shaped crest; interlamellar bristles slightly longer than lamellar, erect, directed mesad, springing from a well developed, short, transverse ridge; exopseudostigmatic bristle also well developed; anteromesal edge of notogaster evanescent (in balsam mounts in dorsal aspect); sides of thorax nodose with a prominent conical, nodose boss dorsad of insertions of legs III (see both figures); bristles ad2 on transverse plane of anterior end of

anal aperture; ad3 midway between apertures; paramesal bristle insertion much smaller; genital cover bristles 2 and 3 widely separated; edge of camerostome not noticeably specialized; size large: total length of body 0.31 to 0.36 mm., breadth 0.17 to 0.19 mm.

Holotype: from log 35, Carlé Woods, Evanston, Ill.; taken March 31st 1937, slide 10,052. Paratypes from same log, slides 10,046 (figured), 10,049 to 10,053.

Suctobelbila spicata lanceolata subsp. nov.

Differs from the species in that notogastral bristles have the distal end compressed-claveolate, that is lanceolate; distal end of pseudostigmatic organs blunt, rounded, with two or three barbs or short bristles, sometimes giving the distal end the appearance of being mucronate.

Cotypes: Ten specimens from litter of old growth oak woods, Shut-in-Ridge (compartment 5, station 17), Bent Creek Exp. Forest, Buncombe Co., N.Car.; taken June 11th, slide 35F3X-20.

The females bear one large egg (occupying one side of abdomen).

Suctobelbella laevis sp. nov.

Figs. 14 and 21

Resembles *S. laxtoni* (14, p. 363, pl. 27, figs. 28-30), but has fine, differently arranged notogastral bristles, and smooth pseudostigmatic organs. Cephaloprothorax short (figure 21); anterior edge of camerostome (ventral edge of rostrum) coarsely toothed, some of the teeth truncate (figure 21); pseudostigmatic organs strongly bent at juncture of pedicel and the long, slender, pointed, compressed head (figures 14 and 21); lamellar and interlamellar crests as in *S. laxtoni* (figure 14); spurs (ribs) of anterior edge of notogaster strongly developed, the mesal broad, with diverging sides, notogastral bristles b1 distant from a1, setting it nearer to b2 than usual, a2 slightly nearer a1 than to b2; size small: total length 0.169 mm., breadth 0.89 mm.

Cotypes: Twenty-seven specimens from litter of laurel slick, north side of Shut-in-Ridge, east of Walnut Cove, Bent Creek Exp. Forest, Buncombe Co., N.Car.; taken May 8th, slide 35F1.3-38.

Oribatula tibialis pallida comb. nov.

Oribatula pallida Banks 1906 (Nov.), p. 494, pl. 18, fig. 28 from Fort Lee, N.J., is the American subspecies of *Oribatula tibilais* 18. I have specimens from blue-grass sod, Mt. Logan, Chillicothe, Ohio, taken by August E. Miller. *Oribata minutus* Ewing 1909 (Sept.), p. 365, pl. 35, fig. 10, is a synonym.

Zygoribatula rostrata sp. nov.

Figs. 17 to 19

Resembles *Z. concolor* (1) p. 11, but rostrum is drawn out (figure 17) and down (figure 18) into a projecting crest; translamella wide enough to allow

of no lamellar cusp; shoulder (anterolateral angle) of notogaster smoothly rounded; pseudostigmatic organs (figures 17 to 19) straight, the head ovate, bluntly pointed, without thickened rim except sometime along one side (figure 18); sides of tectopedia II crenulate or nodose; anterior edge of adalar porose areas not projecting beyond its adjacent bristles; pseudofissura pointing towards mesal bristle; notogastral bristles e1 and d1 equally remote (approximate); anal cover bristles subequally remote; bristles ad2 at corner of aperture; abdomen quite rounded (in dorsal aspect) in females, length 0.428 mm., breadth 0.295 mm.; quite oval (more slender, elongate) in males, length 0.4 mm., breadth 0.25 mm.

Differs from *Zygoribatula brevisetosa* (7, p. 126, pl. 4, fig. 20) in that notogastral bristles are slender and smooth (except shoulder bristles), the lamellar and interlamellar bristles are longer (as long as lamellae), and the pseudostigmatic organ head is very thin (compressed) *Z. brevisetosa* is arboreal, *Z. rostrata* is a geobiont.

Cotypes: Forty-two specimens from blue-grass sod, Mt. Logan, Chillicothe, Ohio; taken September 28th 1925 by August E. Miller, slide 32M44o2.

Scheloribates lanceoliger Berlese.

Galumna sylvicola Banks 1909 (Oct. 5), p. 138, pl. 13, fig. 25 (length 0.38 mm.) from Guelph, Ontario, Canada, is *Scheloribates lanceoliger* Berlese 1908 (Aug. 5) p. 2 (length 0.38 mm.) from Columbia, Missouri. I had gone to Cambridge with a memo to determine how much of the lamellae were free, for Banks' figure had given me the impression that it was free down most of its mesal side. The dark mesal shadow, however, represents the channel running along mesal edge of the lamellae, so conspicuous a feature in this genus. *Oribata helvina* Ewing 1909 (Sept., — issued October 8th) p. 122, pl. 3, figs. 12 and 13 (length 0.38 mm.) fro Urbana, Illinois, is also a synonym.

Ceratozetes gracilis virginica comb. nov.

Galumna virginica Banks 1906 (Nov.), p. 493, pl. 16, figs. 18 and 20, is *Ceratozetes gracilis subaquila curtispina* Jacot 1936 (March), p. 550, figs. 7-9. Thus *Ceratozetes gracilis subaquila* becomes **C. gracilis virginica subaquila** comb. nov. In brief, Banks described the short-cusped form of *C. gracilis* as *virginica*, and Ewing later described the long-cusped form as *subaquila*. They both have the tricusped camerostome, and thus both belong to the same subspecies, as contrasted to the two cusped form *(longispina)*.

Anachipteria signata comb. nov.

Oribatella signata Banks 1895 (Feb.) p. 9 (length 0.45 mm.) from Sea Cliff, Long Island, N.Y., is the species I described and figured as *Anachipteria achipteroides milleri* (12, p. 551, figs. 5, 6). *Oribatella valida* Banks 1910 (Jan.) p. 8, pl. 1, fig. 10 (length 0.5 mm.) from Great Falls, Va., is a synonym. *Sphaerozetes howardi* Berlese 1908, p. 4 (length 0.45 mm.) from

Columbia, Mo., is probably a subspecies. He described the lamellae as similar to those of *Oribates Nicoletii* which he figures in fasc. 3:3 (5) as having distolateral corner cusped. The only discrepancy is that the pseudostigmatic organs are *barely* fusiform. *Oribatella achipteroides* Ewing 1913 (May 31) p. 119, pl. 8, fig. 16 (length 0.54 mm.) from Red Wing, Minn., is a subspecies with distoventral angle of pteromorphae rounded, and slightly pectinate pseudostigmatic organ head. *Oribatella achipteroides australis* Ewing 1917 (Jan. 27) p. 160, pl. 3, figs. 40, 41 (length 0.47 mm.) from Ames, Iowa, is a distinct species with distolateral cusps of lamellae not developed; the pseudostigmatic organ head is very slender.

In the species both lamellae and ventrodistal angle of pteromorphae are pointed, and the distal end of the pseudostigmatic organ head is blunt to pointed or even apiculate.

Phthiracarus luridus Ewing 1909 (Nov.) p. 417, pl. 16, fig. 27.

Fig. 20

Eight specimens from logs, Carlé Woods, Evanston, Ill., taken October 16th and November 30th, 1935, are being referred to this species as they suit the description in all outstanding characteristics.

The Evanston specimens have the following specific characters: Notogastral bristles are very fine, a1 distant from posterior edge of collar, a3 on collar!; pseudostigmatic organs (figure 20) long, cylindrical, the posterior two-thirds with thin center, distal third tapering, thin, bent mesad; rostral bristles not discernible; carina very faint, curving above pseudostigmata (figure 20); accessory plate horn developed.

Pseudotritia ardua (Koch).

Hoplophora arctata Riley 1874, p. 53, fig. 17, is certainly a species of Euphthiracarini because of the slender anogenital area. It is not an Oribotritia because of the erect aspal bristles. I regard it as *Pseudotritia ardua* because that species is quite compressed and a common soil species associated with roots, while species of Euphthiracarus are confined to litter and dead wood. Furthermore, the aspis is not that of most of the species of Euphthiracarus but tapers distad (in lateral aspect) as does that of Pseudotritia.

BIBLIOGRAPHY

1. Banks, 1895 (Feb.)—On the Oribatoidea of the United States.
2. ———1906 (Nov.)—New Oribatidae from the United States.
3. ———1909 (Oct.)—New Canadian Mites.
4. ———1910 (Jan.)—New American Mites.
5. Berlese, 1882-1900—Acari, Myriapoda et Scorpiones hucusque in Italia reperta.
6. ———1908 (Aug. 5)—Elenco di Generi e Specie nuove di Acari.
7. Ewing, 1909 (Sept.)—The Oribatoidea of Illinois.
8. ———1909 (Nov.)—New Species of Acarina.
9. ———1913 (May 31)—Neaw Acarina, Part I.
10. ———1917 (Jan. 27)—Same, Part II.
11. Grandjean, 1934 (Nov. 27)—Observations sur les Oribates (Arach. Acar.).
12. Jacot, 1936 (March)—New Moss-Mites, Chiefly Midwestern.
13. ———1937 (March)—Same, II.
14. ———1937 (Sept.-Dec.)—Journal of North-American Moss-Mites.
15. Michael, 1882 (Feb.)—Further Notes on British Oribatidae.
16. ———1885—New British Oribatidae.
17. ———1888—British Oribatidae, vol. 2.
18. Nicolet, 1855—Histoire Naturelle des Acariens qui se Trouvent aux Environs de Paris.
19. Oudemans, 1914—Acarologisches aus Maulwurfsnestern (Cont.).
20. ———1917 (Dec.)—Notizen über Acari, 25. Reihe.
21. Paoli, 1908—Monografia del Genere *Dameosoma* Berl.
22. Riley, 1874 (April 25)—Descriptions of Two New Subterranean Mites, also Sixth Annual Report on the Noxious, Beneficial and other Insects, of the State of Missouri (p. 53, figs. 17).
23. Willmann, 1928 (March 15)—Neue Oribatiden I.

For further details on the above references see my "Annotated Bibliography of the Moss Mites (Oribatoidea, Acarina)," and its appendices.

Northeastern Forest Exp. Station,
New Haven, Conn.

Generic Check List of Aphids and Phylloxera

Forrest W. Miller

Introduction

The purpose of this check list of Aphid and Phylloxera genera is to compile under one heading all the various generic names set up for these two groups. Several lists have appeared in the past. However, they disagree not only in synonymy but also in citations of journal volumes, pages and dates of publication.

Most of the confusion is due to the inaccessibility of many of the original publications, especially those of foreign sources. In the compilation of this list, original papers were consulted whenever such were available. In a few cases, however, I have been unable to obtain the original papers either because they are out of print or not in the libraries to which I have had access. It is hoped that this list will stimulate an interest which will ultimately bring about more uniformity in aphid and phylloxera taxonomy. I shall welcome correspondence to this end.

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Check List

Abamalekia, del Guercio, 1905, Redia 3:364. MELAPHIS.
Abura, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:407. APHIS.
Acanthaphis, Matsumura, 1918, Trans. N. H. Soc. Sapporo 7:15. MATSUMURAJA.
Acanthocallis, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:367. MYZOCALLIS.
ACANTHOCHERMES, Kollar, 1848, Sitzungber. k. Akad. Wiss. Wien 1:191.
ACAUDELLA, Nevsky, 1929, Zool. Anz. 82:211.
Acaudus, van der Goot, 1913, Tijdschr. Ent. 56:97. ANURAPHIS.
Acyrthosiphon, Mordvilko, 1914, Faune de la Russie pps. 62, 75. MACROSIPHUM.
ADACTYNUS, Rafinesque, 1818, Amer. Mon. Mag. & Crit. Rev. 3:17.
ADELGES, Signoret, 1865, Bull. Soc. Ent. France 5:139.
Agrioaphis, Walker, 1870, The Zoologist p. 2000. MYZOCALLIS.
AICEONA, Takahashi, 1921, Aph. of Formosa 1:85.
AKKAIA, Takahashi, 1919, Insect World 23:439.
ALEUROIDAPHIS, van der Goot, 1916, Con't. Faune Ind. Neérl. 1:239.
Allaphis, Mordvilko, 1921, Puceron des Gram. 1:57. THRIPSAPHIS.
ALPHITOAPHIS, Hottes, 1926, Proc. Biol. Soc. Washington 39:116.
AMPHICERCIDUS, Oestlund, 1922, 19th. Rep. Sta. Ent. Minnesota p. 126.
AMPHOROPHORA, Buckton, 1876, Mon. British Aph. 1:187.

Macrosiphum, Oestlund, 1886.
Macrosiphum, del Guercio, 1886.
Nectarosiphon, Schouteden, 1901.
Eunectarosiphon, del Guercio, 1913.
Rhopalosiphum, van der Goot, 1913.
Rhopalosiphum, del Guercio, 1913.
Clavosiphum, Shinji, 1922.

Amycla, Koch, 1857, Die Pflanzenl. Aph. p. 301. PEMPHIGUS.
Anameson, Mordvilko, 1914, Faune de la Russie p. 63. MACROSIPHUM.
ANCONATUS, Buckton, 1883, Mon. British Aph. 4:177.
ANISOPHLEBA, Koch, 1857, Die Pflanzenl. Aph. p. 320.
ANOECIA, Koch, 1857, Die Pflanzenl. Aph. p. 275.

Schizoneura, Kaltenbach, 1843.

ANOMALAPHIS, Baker, 1920, U.S. Dept. Agr. Bull. 826:52.
ANOMALOSIPHUM, Takahashi, 1934, Stylops Taxonomic Ent. 3:54.
ANURAPHIS, del Guercio, 1907, Redia 4:190.

Brachycaudus, van der Goot, 1913.
Dentatus, van der Goot, 1913.
Semiaphis, van der Goot, 1913.
Acaudus, van der Goot, 1913.
Yezabura, Matsumura, 1917.
Macchiatiella, del Guercio, 1917.
Hannabura, Matsumura, 1917.
Sappaphis, Matsumura, 1918.
Cedoaphis, Oestlund, 1922.
Lachnaphis, Shinji, 1922.
Xerobion, Nevsky, 1928.

ANURIELLA, del Guercio, 1921, Redia 14:113.
AORSION, Mordvilko, 1914, Faune de la Russie p. 72.
Aphanus, Gistl 1837, Faunus n.s. 1:111. PROCIPHILUS.
APHIDIELLA, Theobald, 1923, Ent. Mon. Mag. 59:105.
Aphioides, Rondani, 1847, Nuovi Ann. Soc. Nat. Bologna 8:439. PEMPHIGUS.
Aphioides, Passerini, 1860, Gli Afidi p. 28. PTEROCOMMA.
APHIDULA, Nevsky, 1929, Zool. Anz. 82:208.
APHIS, Linnaeus, 1758, Syst. Nat. p. 451.

Loxerates, Rafinesque, 1817.
Cladoxus, Rafinesque, 1817.
Uraphis, del Guercio, 1907.
Microsiphon, del Guercio, 1913.
Myzaphis, van der Goot, 1913.
Stenaphis, del Guercio, 1913.
Longiunguis, van der Goot, 1916.
Melanaphis, van der Goot, 1916.
Abura, Matsumura, 1917.
Arimakia, Matsumura, 1917.

APHRASTASIA, Borner, 1909, Zool. Anz. 34:498.
APLONEURA, Passerini, 1863, Aph. Italicae p. 78.
Haploneura of some lists.

Tetranema, Derbes, 1869.
Baizongia, Rondani, 1848.

APPELIA, Borner, 1930, Arch. klass. phyl. Ent. 1:113.
Arakawana, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:375. PERIPHYLLUS.
ARCHILACHNUS, Buckton, 1883, Mon. British Aph. 4:177.
Arctaphis, Walker, 1870, The Zoologist p. 2000. CHAITOPHORUS.
Aresha, Mordvilko, 1921, Bull. Sta. reg. Prot. Plantes Petrograd p. 8. CEROSIPHA.
Arimakia, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:405. APHIS.
Aristaphis, Kirkaldy, 1905, Canad. Ent. 37:416. PTEROCOMMA.
ASIPHONAPHIS, Wilson & Davis, 1919, Ent. News 30:39.
ASPIDAPHIS, Gillette, 1917, Canad. Ent. 49:196.
ASIPHONELLA, Theobald, 1922, Bull. Soc. Ent. Egypt 6:76.
ASIPHUM, Koch, 1857, Die Pflanzenl. Aph. p. 246.
Asterolecanium, Westwood, 1879, Gardner's Chron. 12:769. CERATAPHIS.

ASTEGOPTERYX, Karsch, 1890, Ber. deutsch. Bot. Ges. 8:52.

Nipponaphis, Pergande, 1906. *Schizoneuraphis*, van der Goot, 1916.

ATARSOS, Gillette, 1911, Ent. News 22:440.

ATHEROIDES, Haliday, 1839, Amer. Nat. Hist. 2:189.
Aulacorthum, Mordvilko, 1914, Faune de la Russie p. 68. MYZUS.
Baizongia, Rondani, 1848, Nuovi Ann. Sci. Nat. 9:35. APLONEURA.
Betacallis, Matsumura, 1919, Trans. N. H. Soc. Sapporo 7:110. DREPANAPHIS.

BETULAPHIS, Glendenning, 1926, Canad. Ent. 58:96.

BIPERSONA, Hottes, 1926, Proc. Biol. Soc. Washington 39:115.
Boisduvalia, Signoret, 1868, Ann. Soc. Ent. France 8:400. CERATAPHIS.

BRACHYCAUDINA, Borner, 1930, Arch. klass. phyl. Ent. 1:132.
Brachycaudus, van der Goot, 1913, Tijdschr. Ent. 56:97. ANURAPHIS.

BRACHYCOLUS, Buckton, 1879, Mon. British Aph. 2:146.

Brachysiphum van der Goot, 1913.

BRACHYSIPHONIELLA, Takahashi, 1921, Aph. of Formosa 1:62.
Brachysiphum, van der Goot, 1913, Tijdschr. Ent. 56:105. BRACHYCOLUS.
Brachyunguis, Das, 1918, Mem. Indian Mus. 6:227. PERGANDEIDA.
Bradyaphis, Mordvilko, 1894, Varshava U. Izviestiia 8:59. MONAPHIS.

BRAGGIA, Gillette & Palmer, 1929, Ann. Ent. Soc. Amer. 22:28.

BRASILAPHIS, Mordvilko, 1930, Comptes Rendus Acad. Sci. U.R.S.S. p. 277.
Brevicoryne, van der Goot, 1915, Zur. Kennt. Holl. Blattl. p. 245. BREVICORYNE.

BREVICORYNE, Das, 1918, Mem. Ind. Mus. 6:179.

Brevicoryne, van der Goot, 1915. *Thargelia*, Oestlund, 1922.
Oedisiphum, van der Goot, 1916.

BREVICORYNELLA, Nevsky, 1928, Acta Univ. Asiae Mediae 8a 3:21.
Brysocrypta, Haliday, 1839, Amer. Nat. Hist. 2:190. PEMPHIGUS.
Brysocrypta, Westwood, 1840, Int. Nod. Class. Ins. Syn. 2:118. PEMPHIGUS.
Brysocrypta, Tullgren, 1909, Arkiv. f. Zool. 14:182. GOBAISHIA.
Buctonia, Lichtenstein, 1886, Mon. Puc. Peup. p. 16-7. THECABIUS.

BURSAPHIS, Baker, 1934, Ann. Inst. Biol. Mexico 5:217.

CACHRYPHORA, Oestlund, 1922, 19th Rep. Sta. Ent. Minnesota p. 132.

CALAPHIS, Walsh, 1863, Proc. Ent. Soc. Philadelphia 1:301.

Siphonocallis, del Guercio, 1913. *Callipterinella*, van der Goot, 1913.

Callaphis, Walker, 1870, The Zoologist p. 200. CALLIPTERUS.
Callipterinella, van der Goot, 1914, Tijdschr. Ent. 56:118. CALAPHIS.
Callipterinola, Strand, 1928, Arb. Syst. Zool. Inst. U. Lettlaend 27:47. CALLIPTERUS.
Callipteroides, Mordvilko, 1908, Ann. Mus. Zool. Imp. Acad. St. Petersburg 13:377. EUCERAPHIS.
Callipteroides, van der Goot, 1913, Tijdschr. Ent. 56:151. EUCERAPHIS.
Callipterus, Buckton, 1881, Mon British Aph. 3:39. CALLIPTERUS, Koch.

CALLIPTERUS, Koch, 1857, Die Pflanzenl. Aph. p. 208.

Callaphis, Walker, 1870. *Nippocallis*, Matsumura, 1917.
Ptychodes, Buckton, 1881. *Callipterinola*, Strand, 1928.
Panaphis, Kirkaldy, 1904. *Callipterus*, Buckton, 1881.

Callipterus, van der Goot, 1913, Tijdschr. Ent. 56:116. MYZOCALLIS.

CAPITOPHORUS, van der Goot, 1913, Tijdschr. Ent. 56:84.

Cryptomyzus, Oestlund, 1922. *Trilobaphis*, Theobald, 1922.
Francoa, del Guercio, 1917. *Vesiculaphis*, del Guercio, 1911.

Caricaphis, Borner, 1930, Arch. klass. phyl. Ent. 1:24. IZIPHYA.

CAROLINAIA, Wilson, 1911, Canad. Ent. 43:61.

CATAMERGUS, Oestlund, 1922, 19th. Rep. Sta. Ent. Minnesota p. 41.
Obtusicauda, Soliman, 1927.

CAVARIELLA, del Guercio, 1911, Redia 7:323.
Corynosiphon. Mordvilko, 1914.
Nipposiphum. Matsumura, 1917.

Cedoaphis, Oestlund, 1922, 19th. Rep. Sta. Ent. Minnesota p. 127. ANURAPHIS.

CEPEGILLETTEA, Granovsky, 1928, Proc. Ent. Soc. Washington 30:113.

CERATAPHIS, Lichtenstein, 1882, Bull. Soc. Ent. France 2:16.
Coccus, Boisduval, 1867.
Boisduvalia, Signoret, 1868.
Asterolecanium, Westwood, 1879.

CERATOGLYPHINA, van der Goot, 1915, Zur Kennt. Blattl. Java's 1:237.

Ceratovacuna, Zehntner, 1897, Arch. Java Mededl. n.s. 37:29. OREGMA.

Cerciaphis, Theobald, 1920, Bull. Ent. Res. 11:70. SETAPHIS.

CEROSIPHA, del Guercio, 1900, Nuove Rel. Staz. Firenze 1:116.
Aresha, Mordvilko, 1921.
Metaphis, Matsumura, 1918.

CERURAPHIS, Borner, 1926, Abderhaldens Handb. Biol. 9:1.

CERVAPHIS, van der Goot, 1915, Zur Kennt. Blattl. Java's 1:148.
Diverosiphum, Shinji, 1922.

Ceylonia, Buckton, 1891, Ind. Mus. Notes 2:35. TOXOPTERA.

CHAETOPHORUS, see CHAITOPHORUS.

CHAETOSIPHON, Mordvilko, 1914, Faune de la Russie p. 71.

CHAITAPHIS, Nevsky, 1928, Ent. Mitt. 17:197.

CHAITOPHORAPHIS, Shinji, 1923, Dobuts. Zasshi 35:307.

Chaitophorinella, van der Goot, 1913, Tijdschr. Ent. 56:150. PERIPHYLLUS.

CHAITOPHORINUS, Borner, 1930, Arch. klass. phyl. Ent. 1:126.

CHAITOPHOROIDES, Mordvilko, 1908, Ann. Mus. Zool. Imp. Acad. Sci. St. Petersburg 13: 382.

CHAITOPHORUS, Koch, 1854, Die Pflanzenl. Aph. p. 1.

Tranaphis, Walker, 1880.
Arctaphis, Walker, 1870.
Eichochaitophorus, Essig, 1912.
Micrella, Essig, 1912.

Chelymorpha, Clark, 1858, The Microscope p. 112. PERIPHYLLUS.

CHALOPHORUS, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:351.

CHERMAPHIS, Maskill, 1884, N. Zealand Jour. Sci. 2:292.
Kermaphis, Maskill, 1883.

CHERMES, Linnaeus, 1758, Syst. Nat. 10:453.

CHOLODKOVSKYA, Borner, 1909, Zool. Anz. 34:498.

CHROMAPHIS, Walker, 1870, The Zoologist p. 2001.
(Borner, 1930, Arch. klass. phyl. Ent. 1:162 uses CHROMAPHIS to replace Callipterus, Koch.)

CINACIUM, Kishida. 1924, Dobuts. Zasshi 36:472-4.

CINARA, Curtis, 1835, British Ent. Sectn. p. 576.

Dryobius, Koch, 1855.
Tuberolachnus, Mordvilko, 1908.
Dryaphis, del Guercio, 1909.
Lachniella, del Guercio, 1909.
Eulachnus, del Guercio, 1909.
Protolachnus, Theobald, 1915.

Cladobius, Koch, 1857, Die Pflanzenl. Aph. p. 251. PTEROCOMMA.

Cladoxus, Rafinesque, 1817, Amer. Mon. Mag. & Crit. Rev. 1:362. APHIS.

CLAVIGERUS, Szepligeti, 1883, Rovaraszati Lapok 1:4.
Plocamaphis, Oestlund, 1922.
Clavosiphum, Shinji, 1922, Dobuts. Zasshi 34:790. AMPHOROPHORA.
CNAPHALODES, Borner, 1908, Arb. Kais. Biol. Anst. f. Land- u. Forst. 6:167.
Coccus, Boisduval, 1867, Ent. Hortic. p. 355. CERATAPHIS.
COLOPHA, Monell, 1877, Canad. Ent. 9:102.
COLOPHELLA, Borner, 1926, Abderhaldens Handb. Biol. 9:1-2.
Coloradoa, Wilson, 1910, Ann. Ent. Soc. Amer. 3:323. RHOPALOSIPHUM.
CORNAPHIS, Gillette, 1913, Ann. Ent. Soc. Amer. 6:491.
CORYLOBIUM, Mordvilko, 1914, Faune de la Russie p. 71.
Corynosiphon, Mordvilko, 1914, Faune de la Russie p. 73. CAVARIELLA.
Cryptomyzus, Oestlund, 1922, 19th. Rep. Sta. Ent. Minnesota p. 139. CAPITOPHORUS.
CRYPTOSIPHUM, Buckton, 1879, Mon. British Aph. 2:144.
Pseudolachnus, Shinji, 1922.
Ctenocallis, Klodnitski, 1922, Trans. 4th. Russian Ent. Phyto. p. 61.
CUERNAVACA, Baker, 1934, Ann. Inst. Biol. Mexico 5:210.
DACTYLOSPHAERA, Shimer, 1867, Proc. Acad. Nat. Sci. Philadelphia p. 2.
DACTYNOTUS, Rafinesque, 1817, Amer. Mon. Mag. & Crit. Rev. 1:360.
see also 3:15 of the year 1818.
Dasia, van der Goot, 1918, Mem. Ind. Mus. 6:152. PEMPHIGELLA.
Davisia, del Guercio, 1909, Redia 5:185. LONGISTIGMA.
DELPHINIOBIUM, Mordvilko, 1914, Faune de la Russie p. 65.
Dentatus, van der Goot, 1913, Tijdschr. Ent. 56:98. ANURAPHIS.
Dielcysmura, Mordvilko, 1914, Faune de la Russie p. 65. MACROSIPHONIELLA.
Dilachnus, Baker, 1919, Canad. Ent. 51:253. NEOCHMOSIS.
n.n. for *Wilsonia*.
Diverosiphum, Shinji, 1922, Dobuts. Zasshi 34:791. CERVAPHIS.
DORALIS, Leach, 1826, Hist. nat. princ. prod. Europe mer. 5:217.

PERGANDEIDA, Schoteden, 1903. (Probable syn. of Doralis.)

DORAPHIS, Matsumura, 1929, Trans. N.H.Soc. Sapporo 10:102.
DREPANAPHIS, del Guercio, 1909, Rivista di Patol. Vegetal 4:49.
Phymatosiphum, Davis, 1909..
Betacallis, Matsumura, 1919.
Drepaniella, del Guercio, 1913, Redia 9:188. MEGOURA.
Drepaniella, van der Goot, 1916, Tijdschr. Ent. 56:98. MEGOURA.
DREPANOSIPHUM, Koch, 1855, Die Pflanzenl. Aph. p. 201.
Dryaphis, del Guerchio, 1909, Redia 5:262. CINARA.
Dryaphis, Koch, 1855, Die Pflanzenl. Aph. p. 225. LACHNUS.
Dryobius, Koch, 1855, Die Pflanzenl. Aph. p. 225. CINARA.
DRYOPEIA, Kirkaldy, 1904, Entomologist 37:279.
Endeis, Koch, 1857.
Endeis, Ashmead, 1889.
Watabura, Matsumura, 1917.
DUROCAPILLATA, Knowlton, 1927, Ann. Ent. Soc. Amer. 20:229.
DYSAPHIS, Borner, 1931, Anz. Schädlingsk. 7:9.
Eichochaitophorus, Essig, 1912, Pom. Coll. Jour. Ent. 4:721. CHAITOPHORUS.
ELATOBIUM, Mordvilko, 1914, Faune de la Russie p. 72.
Endeis, Koch, 1857, Die Pflanzenl. Aph. p. 312. DRYOPEIA.
Endeis, Ashmead, 1889, Ent. Amer. 5:189. DRYOPEIA.
EPAMEIBAPHIS, Oestlund, 1922, 19th. Rep. Sta. Ent. Minnesota p. 132.
ERIOSOMA, Leach, 1817, Trans. Hort. Soc. London 3:60.

Myzoxyle, Blot, 1824.
Myzoxylus, Blot, 1830.
Myzoxyle, Avrilly, 1834.
Schizoneura, Hartig, 1839.
Mimaphis, Rondani, 1848.

ESSIGELLA, del Guercio, 1909, Rivista di Patol. Vegetal 3:329.
EUAULAX, Mordvilko, 1914, Faune de la Russie, p. 67.
Eucallipterus, Schouteden, 1906, Ann. Ent. Soc. Belgium 12:30. MYZOCALLIS.
Eucarazzia, del Guercio, 1921, Redia 14:134-5. RHOPALOSIPHONINUS.
EUCERAPHIS, Walker, 1870, The Zoologist p. 2001.
Callipteroides, Mordvilko, 1908.
Callipteroides, van der Goot, 1913.
Quippelachnus, Oestlund, 1922.

Eulachnus, del Guercio, 1909, Rivista di Patol. Vegetal 3:329. CINARA.
EUMYZUS, Shinji, 1929, Lansania 1:111.
Eunectarosiphon, del Guercio, 1913, Redia 9:88. AMPHOROPHORA.
EURYTHAPHIS, Mordvilko, 1914, Faune de la Russie p. 66.
EUTRICHOSIPHUM, Essig & Kuwana, 1918, Proc. Calif. Acad. Sci. 8:97.
Goodea, Shinji, 1922.

FLABELLOMICROSIPHUM, Gillette & Palmer, 1932, Ann. Ent. Soc. Amer. 25:472.
FORDA, Heyden, 1837, Mus. Senckenberg 2:291.
Rhizoterus, Hartig, 1841.
Smynthurodes, Westwood, 1849.
Pentaphis, Horvath, 1896.
Pentaphis, del Guercio, 1909.
Rectinasus, Theobald, 1914.

FORMOSAPHIS, Takahashi, 1925, Aph. of Formosa 4:52.
Francoa, del Guercio, 1917, Redia 12:197 and 201.
(Probable syn of CAPITOPHORUS.)

FULLAWAYA, Essig, 1912, Pom. Coll. Jour. Ent. 4:735.
FULLAWAYELLA, del Guercio, 1911, Redia 7:462.
Neotoxoptera, Theobald, 1915.
(Probable syn. of IDIOPTERUS, Davis.)

Fushia, Matsumura, 1917, Essays Nawa p. 70. NURUDEA.
GALOBIUM, Borner, 1933, Kleine Mitt. Blattl. p. 4.
GEOICA, Hartig, 1894, Rep. Ins. Illinois 18:101.
Tychea, Passerini, 1860.
Tycheoides, Schouteden, 1906.
Kaltenbachiella, Schouteden, 1906.
Trifidaphis, del Guercio, 1909.
Tullgrenia, van der Goot, 1912.
Trinacriella, del Guercio, 1913.
Serrataphis, van der Goot, 1916.

GEOKTAPIA, Mordvilko, 1921, Bull. Petrograd Div. Sts. Prot. Plantes 3:72.
GEOPEMPHIGUS, Hille Ris Lambers, 1933, Stylops Taxonomic Ent. 2:198.
Georgia, Wilson, 1911, Canad. Ent. 43:64. GEORGIAPHIS.
GEORGIAPHIS, Hottes & Maxson, 1926, Ent. News 37:266.
(n.n. for *Georgia*, Wilson.)
Gillettea, Borner, 1909, Zool. Anz. 34:504. GILLETEELLA.
GILLETTEELLA, Borner, 1930, Arch. klass. phyl. Ent. 1: 157.
Gillettea, Borner, 1909.

GISTELIELLA, Strand, 1928, Arch. Naturg. 92:46.
Glyphina, Koch, 1857, Die Pflanzenl. Aph. p. 259. THELAXES.

GLYPHINAPHIS, van der Goot, 1916, Zur Kennt. Blattl. Java's p. 232.
GOBAISHIA, Matsumura, 1917, Essays Nawa p. 75.
Brysocrypta, Tullgren, 1909.
Goodea, Shinji, 1922, Dobuts. Zasshi 34:793. EUTRICHOSIPHUM.
GOOTIELLA, Tullgren, 1925, Medd. Centralanst. 280:22.
Greenidea, Schouteden, 1905, Spolia Zeylan 2:181. GREENIDEOIDA.
Trichosiphum, Pergande, 1906.
GREENIDEOIDA, van der Goot, 1916, Con't. Faune Ind. Néerl. 1:142.
Greenidea, Schouteden, 1905.
Greenideoida, van der Goot, 1916.
Greenideoida, van der Goot, 1916, Zur Kennt. Blattl. Java's p. 140. GREENIDEOIDA.
GYPSOAPHIS, Oestlund, 1922, 19th Rep. Sta. Ent. Minnesota. p. 126.
HALMODAPHIS, Mordvilko, 1914, Faune de la Russie p. 66.
Hamadryaphis, Kirkaldy, 1904, Entomologist 37:279. PEMPHIGUS.
HAMAMELISTES, Shimer, 1867, Trans. Amer. Ent. Soc. 1:284.
Tetraphis, Horvath, 1896.
Hannabura, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:377. ANURAPHIS.
Hayhurstia, del Guercio, 1917, Redia 12:206. HYALOPTERUS.
Hemiaphis, Borner, 1926, Abderhaldens Handb. Biol. 9:126. PERGANDEIDA.
HEMITRAMA, Mordvilko, 1921, Bull. Petrograd Div. Sta. Prot. Plantes 3:72.
Hetroneura, Davis, 1919, Canad. Ent. 51:228. HYSTERONEURA.
Holzneria, Lichtenstein, 1875, Bull. Soc. Ent. France 5:76. PROCIPHILLUS.
HOPLOCHAITOPHORUS, Granovsky, 1933, Proc. Ent. Soc. Washington 35:32.
HORMAPHIS, Osten-Sachen, 1861, Stettin Ent. Zeit. 22:422.
HYADAPHIS, Kirkaldy, 1904, Entomoligost 37:279.
Siphocoryne, Passerini, 1863.
HYALOPTEROIDES, Theobald, 1916, Entobogist 49:51.
HYALOPTERUS, Koch, 1854, Die Pflanzenl. Aph. p. 16.
Hayhurstia, del Guercio, 1917.
HYDRONAPHIS, Shinji, 1922, Dobuts. Zasshi 34:790.
HYDROMYZUS, Borner, 1933, Kleine Mitt. Blattl. p. 2.
HYSTERONEURA, Davis, 1919, Canad. Ent. 51: 228 and 263.
n.n. for *Heteroneura*.
HYSTRICHIELLA, Borner, 1910, Zool. Anz. 33:609.
IDIOPTERUS, Davis, 1909, Ann. Ent. Soc. Amer. 2:199.
Illinoia, Wilson, 1910, Ann. Ent. Soc. Amer. 3:318. MACROSIPHUM.
IMPATIENTINUM, Mordvilko, 1914, Faune de la Russie p. 72.
IZIPHYA, Nevsky, 1929, V. P. Uzbekistan Exp. Sta. Plant Prot. 16:314.
Caricaphis, Borner, 1930.
Jacksonia, Theobald, 1923, Scottish Nat. p. 9. MYZUS.
JAXARTAPHIS, Mordvilko, 1914, Faune de la Russie p. 65.
KAKIMIA, 1931, Hottes & Frison, Aph. of Illinois p. 344.
Kallistaphis, Kirkaldy, 1905, Canad. Ent. 37:417. MYZOCALLIS.
Kaltenbachiella, Schouteden, 1906, Mem. Soc. Ent. Belgium 12:195. GEOICA.
Kermaphis, Maskell, 1883, Trans. N. Zeal. Inst. 17:16. CHERMAPHIS.
Kessleria, Lichtenstein, 1886, Mon. Puc. Peup. p. 16. PEMPHIGUS.
KURISAKIA, Takahashi, 1924, Philadelphia Jour. Sci. 24:715.
Lachnaphis, Shinji, 1922, Dobuts. Zasshi 34:729. ANURAPHIS.
Lachniella, del Guercio, 1909, Redia 5:268. CINARA.
LACHNOCHAITOPHORUS, Granovsky, 1933, Proc. Ent. Soc. Washington 35:33.
LACHNUS, Burmeister, 1835, Handb. der Ent. 2:91.

Pterochlorus, Rondani, 1848.
Dryaphis, Koch, 1855.
Schizodryobius, van der Goot, 1913.
Pterochloroides, Archangelsky, 1917.
Tuberodryobius, Das, 1918.
Maculolachnus, Gaumont, 1920.

LAINGIA, Theobald, 1922, Bull. Ent. Res. 12:429.

LIOSOMAPHIS, Walker, 1870, The Zoologist p. 1119.
Lowia, Lichtenstein, 1886, Mon. Puc. Peup. p. 37. PHLOEOMYZUS.
Longicaudus, van der Goot, 1913, Tijdschr. Ent. 56:146. PERGANDEIDA.

LONGISTIGMA, Wilson, 1909, Canad. Ent. 41:385.
Davisia, del Guercio, 1909.

Longiunguis, van der Goot, Con't. Faune Ind. Neérl. 1:112. APHIS.
Loxerates, Rafinesque, 1817, Amer. Mon. Mag. & Crit. Rev. 1:361. APHIS.
Lutaphis, Shinji, 1924, Dobuts. Zasshi 36:347. MYZOCALLIS.
Macchiatiella, del Guercio, 1917, Redia 12:210. ANURAPHIS.

MACROCAUDUS, Shinji, 1934, Lansania 2:79.
Macrosiphon, del Guercio, 1913, Redia 9:187-8. MACROSIPHUM.

MACROSIPHONIELLA, del Guerchio, 1911, Redia 7:331.
Macrosiphum, van der Goot, 1913.
Dielcysmura, Mordvilko, 1914.

Macrosiphum, Oestlund, 1886, Rep. Surv. Minnesota 14:27. AMPHOROPHORA.
Macrosiphum, del Guercio, 1900, Nuovi Rel. Staz. Fierenze 1:159. AMPHOROPHORA.

MACROSIPHUM, Passerini, 1860, Gli Afidi p. 27.

Siphonophora, Koch, 1855.
Nectarophora, Oestlund, 1887.
Illinoia, Wilson, 1910.
Macrosiphon, del Guercio, 1913.
Acyrthosiphon, Mordvilko, 1914.
Metopeurum, Mordvilko, 1914.
Anameson, Mordvilko. 1914.

Macrosiphum, van der Goot, 1913, Tijdschr. Ent. 56:145. MACROSIPHONIELLA.

MACULODRYAPHIS, Gaumont, 1923, Ann. Epiphyties 9:340.
Maculolachnus, Gaumont, 1920, Bull. Soc. Ent. France 26:30. LACHNUS.

MANSAKIA, Matsumura, 1917, Essays Nawa p. 59.

MASTOPODA, Oestlund, 1886, Rep. Surv. Minnesota 14:53.

MATSUMURAJA, Schumacher, 1921, Zool. Anz. 53:186.
(n.n. for *Acanthaphis*.)

MEGOURA, Buckton, 1876, Mon. British Aph. 1:188.
Drepaniella, del Guercio, 1913.
Drepaniella, van der Goot, 1916.
Tuberosiphum, Shinji, 1922.

Melanaphis, van der Goot, Con't. Faune Ind. Neérl. 1:61. APHIS.

MELANOCALLIS, Oestlund, 1922, 19th. Rep. Sta. Ent. Minnesota p. 136.
Melanoxantherium, Schouteden, 1901, Bull. & Ann. Ent.. Soc. Belgium 45:113. PTEROCOMMA.
Melanoxanthus, Buckton, 1879, Mon. British Aph. 2:21. PTEROCOMMA.

MELAPHIS, Walsh, 1866, Proc. Ent. Soc. Philadelphia 6:281.
Schlechtendalia, Lichtenstein, 1883.
Abamalekia, del Guercio, 1905.

MESOCALLIS, Matsumura, 1919, Trans. N.H.Soc. Sapporo 7:103.
Metaphis, Matsumura, 1919, Trans. N.H.Soc. Sapporo 7:109. CEROSIPHA.
Metopeurum, Mordvilko, 1914, Faune de la Russie p. 67. MACROSIPHUM.

MICRAPHIS, Takahashi, 1931, Rep. Gov. Res. Inst. Formosa 53:53.
Micrella, Essig, 1912, Pom. Coll. Jour. Ent. 4:716. CHAITOPHORUS.

MICROPARSUS, Patch, 1909, Ent. News 20:337.

MICROMYZUS, van der Goot, 1916, Zur Kennt. Blattl. Java's p. 55.
Microsiphon, del Guercio, 1907, Redia 4:192. APHIS.

MICROSIPHUM, Cholodkovsky, 1902, Isviestiya St. Petersburg Ins. p. 53.
MICROTARSUS, Shinji, 1929, Lansania 1:43.
Mimaphis, Rondani, 1848, Nuovi. Ann. delle Sci. Nat. 9:35. ERIOSOMA.
MIMOCALLIS, Matsumura, 1919, Trans. N.H.Soc. Sapporo 7:102.
MINDARUS, Koch, 1857, Die Pflanzenl. Aph. p. 277.
MINUTICORNICUS, Knowlton, 1928, Florida Ent. 12:59.
MIRAPHIS, Nevsky, 1928, Acta Univ. Asiae, Mediae 8:25.
MONAPHIS, Walker, 1870, The Zoologist p. 2001.
Bradyaphis, Mordvilko, 1894.
MONELLIA, Oestlund, 1887, Geol. N.H.Surv. Minnesota 4:44.
MORDWILKOJA, del Guercio, 1909, Rivista di Patol. Vegetal 4:11.
MORITZIELLA, Borner, 1908, Zool. Anz. 33:608.
MUSCAPHIS, Borner, 1933, Kleine Mitt. Blattl. p. 4.
Myzaphis, van der Goot, 1913, Tijdschr. Ent. 56:96. APHIS.
MYZOCALLIS, Passerini, 1860, Gli Afidi p. 28.

Pterocallis, Passerini, 1860.
Therioaphis, Walker, 1870.
Agrioaphis, Walker, 1870.
Callipterus, Buckton, 1881.
Tuberculatus, Mordvilko, 1894.
Subcallipterus, Mordvilko, 1894.
Eucallipterus, Schouteden, 1906.
Kallistaphis, Kirkaldy, 1905.
Callipterus, van der Goot, 1913.
Pterocallis, Mordvilko, 1914.
Neocallipterus, van der Goot, 1915.
Tuberculoides, van der Goot, 1915.
Acanthocallis, Matsumura, 1917.
Takecallis, Matsumura, 1917.
Neocallis, Matsumura, 1919.
Tinocallis, Matsumura, 1919.
Sarucallis, Shinji, 1922.
Lutaphis, Shinji, 1924.
Tuberocallis, Nevsky, 1929.

Myzodes, Mordvilko, 1914, Faune de la Russie p. 52 and 69. MYZUS.
Myzoides, van der Goot, 1913, Tijdschr. Ent. 56:84. MYZUS.
Myzopsis, Matsumura, 1918, Trans. N. H. Soc. Sapporo 7:19. MYZUS.
MYZOTOXOPTERA, Theobald, 1927, Entomologist 60:31.
Myzoxyle, Avrilly, 1834, Du Myzoxyle 1:1. ERIOSOMA.
Myzoxyle, Blot, 1824, Mem. Soc. Linn. Calvados p. 1. ERIOSOMA.
Myzoxylus, Blot, 1830, Mem. Roy. Agr. Soc. Caen. 3:332. ERIOSOMA.
MYZUS, Passerini, 1860, Gli Afidi p. 27.

Rhopalosiphum, Passerini, 1860.
Myzoides, van der Goot, 1913.
Ovatus, van der Goot, 1913.
Myzodes, Mordvilko, 1914.
Aulacorthum, Mordvilko, 1914.
Neomyzus, van der Goot, 1916.
Myzopsis, Matsumura, 1918.
Jacksonia, Theobald, 1923.

NASONOVIA, Mordvilko, 1914, Faune de la Russie p. 72.
NEANURAPHIS, Nevsky, 1928, Ent. Mitt. 17:193.
NEAPHIS, Nevsky, 1929, Zool. Anz. 82:206.
Nectarophora, Oestlund, 1887, Rep. Surv. Minnesota 4:78. MACROSIPHUM.
Nectarosiphon, Schouteden, 1901, Ann. Ent. Soc. Belgium 45:112. AMPHOROPHORA.
NEOACAUDUS, Theobald, 1927, Aph. of England 2:326.
NEOAMPHOROPHORA, Mason, 1924, Proc. Ent. Soc. Washington 26:49
Neocallipterus, van der Goot, 1915, Zur Kennt. Holl. Blattl. p. 319. MYZOCALLIS.
Neocallis, Matsumura, 1919, Trans. N. H. Soc. Sapporo 7:105. MYZOCALLIS.
NEOCAVARIELLA, Shinji, 1922, Dobuts. Zasshi 34:122.
NEOCHMOSIS, Theobald, 1929, Aph. of England 3:129.
n. n. for *Panimerus*, Laing.
Wilsonia, Baker, 1919.
Dilachnus, Baker, 1919.

NEOCHROMAPHIS, Takahashi, 1921, Jap. Aphididae, 1:24.
NEOLACHNAPHIS, Shinji, 1924, Dobuts. Zasshi 36:352.
NEOMYZAPHIS, Theobald, 1926, Aph. of England 1:262.
Neomyzus, van der Goot, 1916, Con't. Faune Ind. Néerl. 1:50. MYZUS.
NEONIPPOLACHNUS, Shinji, 1924, Dobuts Zasshi 33:343.
NEOPHORODON, Takahashi, 1922, Proc. Ent. Soc. Washington 24:204.
NEOPHYLLAPHIS, Takahashi, 1920, Canad. Ent. 52:19.
NEOPROCIPHILUS, Patch, 1912, Maine Agr. Exp. Sta. Bull. 202:174.
NEORHIZOBIUS, del Guercio, 1917, Redia 12:251.
NEOSCHOUTEDENIA, Schumacher, 1923, Zeit. Ent. p. 403.
NEOSYMYDOBIUS, Baker, 1920, U. S. Dept. Agr. Bull. 826:32.
Neothomasia, Baker, 1920, U. S. Dept. Agr. Bull. 826:35. THOMASINIELLULA.
NEOTRAMA, Baker, 1920, U. S. Dept. Agr. Bull. 826:20.
Neotoxoptera, Theobald, 1915, Bull. Ent. Res. 6:131. FULLAWAYELLA.
NESIOPE, Kirkaldy, 1908, Proc. Linn. Soc. New So. Wales 33:389.
Nippocallis, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:365. CALLIPTERUS.
NIPPOLACHNUS, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:382.
Nipposiphum, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:410. CAVARIELLA.
Nipponaphis, Pergande, 1906, Ent. News 17:205. ASTEGOPTERYX.
Nishiyana, Matsumura, 1917, Essays Nawa p. 90. PROCIPHILUS.
NOTABILIA, Mordvilko, 1908, Ann. Mus. Zool. Imp. Acad. Sci. St. Petersburg 13:362.
NURUDEA, Matsumura, 1917, Essays Nawa p. 65.
Nurudeopsis, Matsumura, 1917.
Fushia, Matsumura, 1917.
Nurudeopsis, Matsumura, 1917, Essays Nawa p. 67. NURUDEA.
Obtusicauda, Soliman, 1927, U. Calif. Pub. Ent. 4:98. CATAMERGUS.
Oedisiphum, van der Goot, 1916, Con't. Faune Ind. Néerl. 1:123. BREVICORYNE.
OESTLUNDIELLA, Granovsky, 1930, Proc. Ent. Soc. Washington 32:63.
n.n. for *Quippelachnus*, Oestlund.
OKAJIMAIA, Suenaja, 1933, Kontyu 7:250.
OREGMA, Buckton, 1893, Ind. Mus. Notes 3:87.
Ceratovacuna, Zehntner, 1897.
OROBION, Mordvilko, 1914, Faune de la Russie p. 67.
Ovatus, van der Goot, 1913, Tijdschr. Ent. 56:84. MYZUS.
Pachypappa, Tullgren, 1909, Arkiv. f. Zool. 14:69. PEMPHIGUS.
Pachypapa, Koch, 1857, Die Pflanzenl. Aph. p. 269. PEMPHIGUS.
Pachypappella, Baker, 1920, U. S. Dept. Agr. Bull. 826:71. PEMPHIGUS.
n.n for *Pachypappa*, Tullgren, 1909.
PACZOSKIA, Mordvilko, 1914, Faune de la Russie p. 63. (key)
1919, Faune de la Russie p. 330. (desc.)
PADUCIA, Hottes & Frison, 1931, Aph. of Illinois p. 167.
Panaphis, Kirkaldy, 1904, Entomologist 37:279. CALLIPTERUS.
Panimerus, Laing, 1927, Entomologist 59:329. NEOCHMOSIS.
n.n. for *Dilachnus*, Baker,, 1919.
PAOLIELLA, Theobald, 1928, Bull. Ent. Res. 19:177.
Paracletius, Amyot, 1843, Ann. Ent. Soc. France 5: 487, 543. PARACLETUS.
PARACLETUS, Heyden, 1837, Mus. Senckenberg 2:295.
Paracletius, Amyot, 1843.
PARAMYZUS, Borner, 1933, Kleine Mitt. Blattl. p. 4.
PARAPERGANDEA, Borner, 1930, Arch. klass. phyl. Ent. 1:160.
PARATRICHOSIPHUM, Takahashi, 1931, Rep. Gov. Res. Inst. Formosa 53:32.

PATCHIA, Baker, 1920, U. S. Dept. Agr. Bull. 826:34.
PEMPHIGELLA, Tullgren, 1909, Arkiv. f. Zool. 5:171.
Dasia, van der Goot, 1918.
PEMPHIGETUM, Mordvilko, 1928, Bull. Soc. Zool. France 53:359.
PEMPHIGINUS, Borner, Arch. klass. phyl. Ent. 1:153.
PEMPHIGLACHNUS, Knowlton, 1928, Ann. Ent. Soc. Amer. 21:264.
PEMPHIGUS, Hartig, 1837, Jahresh. v.d. Forts. d. Forst. *1*(4):645.

Brysocrypta, Haliday, 1839.
Brysocrypta, Westwood, 1840.
Amphioides, Rondani, 1847.
Amycla, Koch, 1857.
Pachypappa, Koch, 1857.
Rhizomaria, Hartig, 1857.
Tychea, Koch, 1857.
Kessleria, Lichtenstein, 1885.
Hamadryaphis, Kirkaldy, 1904.
Pachypappa, Tullgren, 1909.
Pachypappella, Baker, 1920.

PENTALONIA, Coquerel, 1859, Ann. Ent. Soc. France 7:259.
Pentaphis, Horvath, 1896, Wien Ent. Zeit. 15:2. FORDA.
Pentaphis, del Guercio, 1909, Rivista di Patol. Vegetal 3:332. FORDA.
PENTATRICHOPUS, Borner, 1930, Arch. klass. phyl. Ent. 1:140.
PERGANDEIDA, Schouteden, 1903, Zool. Anz. 26:685.

Longicaudus, van der Goot, 1913.
Rhizoberlesia, del Guercio, 1915.
Yezosiphum, Matsumura, 1918.
Brachyunguis, Das, 1918.
Hemiaphis, Borner, 1926.
Xerophilaphis, Nevsky, 1928.

PERIPHYLLUS, van der Hoeven, 1863, Tijdschr. Ent. 6:7.

Phillophorus, Thornton, 1852.
Chelymorpha, Clark, 1858.
Chaitophorinella, van der Goot, 1913.
Arakawana, Matsumura, 1917.

PHARALIS, Leach, 1826, Hist. nat. princ. prod. Europe mer. 5:217.
Phillophorus, Thornton, 1852, Proc. Ent. Soc. London 2:78. PERIPHYLLUS.
PHLAEOMYZUS, n.n. for *Phloeomyzus*, Horvath.
Phloeomyzus, Horvath, 1896, Wien Ent. Zeit. 15:6. PHLAEOMYZUS.
n.n. for *Lowia*, Lichtenstein, 1886.
PHORODON ,Passerini, 1860, Gli Afidi p. 27.
PHYLLAPHIS, Koch, 1857, Die Pflanzenl. Aph. p. 248.
Shivaphis, Das, 1918.
PHYLLAPHOIDES, Takahashi, 1921, Aph. of Formosa 1:75.
Trichocallis, Borner, 1930.
PHYLLOXERA, Boyer, 1834, Ann. Ent. Soc. France 3:222.
PHYLLOXERINA, Borner, 1908, Arb. Kais. Biol. Anst. f. Land- u. Forst. 6:81.
Phymatosiphum, Davis, 1909, Ann. Ent. Soc. Amer. 2:196. DREPANAPHIS.
PINEUS, Shimer, 1869, Trans. Amer. Ent. Soc. 2:383.
Plocamaphis, Oestlund, 1922, 19th. Rep. Sta. Ent. Minnesota p. 122. CLAVIGERUS.
PROCIPHILUS, Koch, 1857, Die Pflanzenl. Aph. p. 279.

Aphanus, Gistl, 1837.
Stagonia, Koch, 1857.
Holzneria, Lichtenstein, 1875.
Nishiyana, Matsumura, 1917.

Protolachnus, Theobald, 1915, Bull. Ent. Res. 6:145. CINARA.
PROTRAMA, Baker, 1920, U. S. Dept. Agr. Bull. 826:19.
PSEUDOEPAMEIBAPHIS, Gillette & Palmer, 1932, Ann. Ent. Soc. Amer. 25:145.
Pseudolachnus, Shinji, 1922, Dobuts. Zasshi 34:730. CRYPTOSIPHUM.
PSEUDOMEGOURA, Shinji, 1929, Lansania 1:112.

PSYLLOPTERA Ferreri, 1864, Ann. Mus. Genova 1:85.
PTERIAPHIS, Gaumont, 1923, Ann. Epiphyties 9:1.
Pterocallis, Passerini, 1860, Gli Afidi p. 28. MYZOCALLIS.
PTEROCALLIS, Schouteden, 1906, Ann. Ent. Soc. Belgium 50:31.
Pterocallis, Mordvilko, 1914, Faune de la Russie p. 56. MYZOCALLIS.
PTEROCHLORODES, Mordvilko, 1914, Faune de la Russie p. 23.
Pterochloroides, Archangelsky, 1917, Turkestan Ent. Sta. Rep. Tashkent. LACHNUS.
Pterochlorus, Rondani, 1848, Nuovi Ann. delle Sci. Nat. p. 35. LACHNUS.
PTEROCOMMA, Buckton, 1879, Mon. British Aph. 2:142.

Cladobius, Koch, 1857.
Aphioides, Passerini, 1860.
Melanoxanthus, Buckton, 1879.
Melanoxantherium, Schouteden, 1901.
Aristaphis, Kirkaldy, 1905.

PTEROSTIGMA, Buckton, 1883, Mon. British Aph. 4:178.
Ptychodes, Buckton, 1881, Mon British Aph. 3:39. CALLIPTERUS.
PYRAPHIS, Borner, 1931, Anz. Schädlingsk. 7:10.
Quippelachnus, Oestlund, 1922, 19th. Rep. Sta. Ent. Minnesota p. 134. EUCERAPHIS
(See also OESTLUNDIELLA.)
RECTICALLIS, Matsumura, 1919, Trans. N. H. Soc. Sapporo 7:105.
Rectinasus, Theobald, 1914, Entomologist 47:28. FORDA.
Rhizoberlesia, del Guercio, 1915, Redia 10:246. PERGANDEIDA.
Rhizobius, Westwood, 1845, Trans. Ent. Soc. 10:71. TRAMA.
RHIZOBIUS, Burmeister, 1835, Handb. Ent. 2:78.

Rhizophthiridum, van der Hoeven, 1849.
Rhyzoicus, Passerini, 1860.
Rizobius, Passerini, 1863.
Rhizoicus, del Guercio, 1917.

RHIZOCTONUS, Mokrzhetsky, 1897, Trudy Russian Ent. 30:438.
(Cholodkovsky credits Horvath with this genus.)
Rhizomaria, Hartig, 1857, Verh. d. Hils.-Soll. Forst. p. 52. PEMPHIGUS.
Rhizophthiridum, van der Hoeven, 1849, Handb. Dierkunde 1:508. RHIZOBIUS.
Rhizoterus, Hartig, 1841, Zeit. Ent. 3:363. FORDA.
RHOPALOSIPHONINUS, Baker, 1920, U. S. Dept. Agr. Bull. 826:58.
Eucarazzia, del Guercio, 1921.
RHOPALOSIPHUM, Koch, 1854, Die Pflanzenl. Aph. p. 23.

Siphocoryne, Passerini, 1860.
Coloradoa, Wilson, 1910.
Siphonaphis, van der Goot, 1915.
Stephensonia, Das, 1918.

Rhopalosiphum, van der Goot, 1913, Tijdschr. Ent. 56:146. AMPHOROPHORA.
Rhopalosiphum, Passerini, 1860, Gli Afidi p. 27. MYZUS, Pass.
Rhopalosiphum, del Guercio, 1913, Redia 9:188. AMPHOROPHORA.
Rhynchocles, Altum, 1881, Forst Zoology 3:356. STOMAPHIS.
Rhyzoicus, Passerini, 1860, Gli Afidi p. 30. RHIZOBIUS.
Rhizoicus, del Guercio, 1917, Redia, 12:251. RHIZOBIUS.
Rizobius, Passerini, 1863, Aph. Italicae p. 79. RHIZOBIUS.
RUNGSIA, Momeur, 1923, Bull. Soc. Nat. Sci. Morocco 13:104.
SALTUSAPHIS, Theobald, 1915, Bull. Ent. Res. 6:138.
SANBORNIA, Baker, 1920, U. S. Dept. Agr. Bull. 826:50.
Sappaphis, Matsumura, 1919, Trans. N. H. Soc. Sapporo 7:18. ANURAPHIS
SAPPOCALLIS, Matsumura, 1919, Trans N. H. Soc. Sapporo 7:108.
Sarucallis, Shinji, 1922, Dobuts. Zasshi 34:730. MYZOCALLIS.
SCHENAHWEUM, Hottes & Frison, 1931, Aph. of Illinois 267.
SCHIZAPHIS, Borner, 1931, Anz. Schädlingsk 7:10.

Schizodryobius, van der Goot, 1913, Tijdschr. Ent. 56:130. LACHNUS.
SCHIZOLACHNUS, Mordvilko, 1908, Ann. Mus. Zool. Imp. Acad. Sci. St. Petersburg 13:375.
Schizoneura, Hartig, 1837, Jahresb. v.d. Forts. d. Forst. 1(4):645. ERIOSOMA.
Schizoneura, Kaltenbach, 1843, Mon. Pflanzenl. p. 167. ANOECIA.
Schizoneuraphis, van der Goot, 1916, Con't. Faune Ind. Néerl. 3:245. ASTEGOPTERYX.
SCHIZONEUROIDES, Buckton, 1883, Mon. British Aph. 4:178.
Schlectendalia, Lichtenstein, 1883, Stettin. Ent. Zeit. 44:240. MELAPHIS.
SCHOUTEDENIA, Rubsaamen, 1905, Marcellia 4:19.
Semiaphis, van der Goot, 1913, Tijdschr. Ent. 56:105. ANURAPHIS.
Serrataphis, van der Goot, 1916, Con't. Faune Ind. Néerl. 3:265. GEOICA.
SETAPHIS, van der Goot, 1916, Con't. Faune Ind. Néerl. 3:153.
Cerciaphis, Theobald, 1920.
Shivaphis, Das, 1918, Mem. Ind. Mus. 6:245. PHYLLAPHIS.
SIPHA, Passerini, 1860, Gli Afidi p. 29.
Siphocoryne, Passerini, 1860, Gli Afidi p. 28. RHOPALOSIPHUM.
Siphocoryne, Passerini, 1863, Aph. Italicae p. 8. HYADAPHIS.
SIPHONATROPHIA, Swain, 1918, Ent. News 29:363.
Siphonaphis, van der Goot, 1915, Zur Kennt. Holl. Blattl. p. 238. RHOPALOSIPHUM.
Siphonocallis, del Guercio, 1913, Redia 9:293. CALAPHIS.
SIPHONOCORYNE, Shinji, 1922, Dobuts. Zasshi 34:793.
Siphonophora, Koch, 1855, Die Pflanzenl. Aph. p. 150. MACROSIPHUM.
SIPHONOPHORAPHOIDES, Buckton, 1883, Mon. British Aph. 4:176.
SITOBIUM, Mordvilko, 1914, Faune de la Russie p. 65. (key)
1921, Pucerons des Gram. 1:43. (desc.)
SLAVUM, Mordvilko, 1927, Mem. Soc. Zool. France 28:74.
SMIELA, Mordvilko, 1929, Trudy Ent. Plant Prot. Leningrad 14:50.
Smynthurodes, Westwood, 1849, Gardner's Chron. p. 420. FORDA.
SOMAPHIS, Shinji, 1929, Lansania 1:110.
SOTOBIUM, Mordvilko, 1914, Faune de la Russie p. 65.
Stagonia, Koch, 1857, Die Pflanzenl. Aph. p. 284. PROCIPHILUS.
STATICOBIUM, Mordvilko, 1914, Faune de la Russie p. 66.
STEGOPHYLLA, Oestlund, 1922, 19th. Rep. Sta. Ent. Minnesota p. 146.
Stenaphis, del Guercio, 1913, Redia 9:185. APHIS.
Stephensonia, Das, 1918, Mem. Ind. Mus. 6:175. RHOPALOSIPHUM.
STOMAPHIS, Walker, 1870, The Zoologist p. 2000.
Rhynchocles, Altum, 1881.
SUBCALLIPTERUS, Schouteden, 1906, Ann. Ent. Soc. Belgium 50:31.
SUBCALLIPTERUS, Mordvilko, 1894, Varshava U. Izviestiis 8: 53. MYZOCALLIS.
SUBMACROSIPHUM, Hille Ris Lambers, 1931, Mem. Mus. Stor. Nat. Venezia. 1:22.
SUMATRAPHIS, Takahashi, 1935, Misc. Zool. Sumatra 97:2.
SYMYDOBIUS, Mordvilko, 1894, Varshava U. Izviestiis 8:65.
Yezocallis, Matsumura, 1917.
TAIWANAPHIS, Takahashi, 1934, Stylops Taxonomic Ent. 3:56.
Takecallis, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:373. MYZOCALLIS.
TAMALIA, Baker, 1920, U. S. Dept. Agr. Bull. 826:24.
Tavaresiella, del Guercio, 1911, Redia, 7:299. THELAXES.
TELOCALLIS, Shinji, 1922, Dobuts. Zasshi 34:731.
TERMITAPHIS, Wasman, 1902, Tijdschr. Ent. 45:105.

TERMITOCORIDAE, Silvestri, 1911, Boll. Lab. di Zool. e Agraria Portici 5:232.
TETRANEURA, Hartig, 1841, Zeit. Ent. 3:366.
Tetranema, Derbes, 1896, Acad. des Sci. Nat. Zool. 11:106. APLONEURA.
TETRAPHIS, Horvath, 1896, Wien Ent. Zeit. 15:6. HAMAMELISTES.
Thargelia, Oestlund, 1922, 19th. Rep. Sta. Ent. Minnesota p. 127. BREVICORYNE.
THECABIUS, Koch, 1857, Die Pflanzenl. Aph. p. 294.
Bucktonia, Lichtenstein, 1886.
THELAXES, Westwood, 1840, Int. Mod. Class. Ins. Syn. 2:118.
Vacuna, Heyden, 1837.
Glyphina, Koch, 1857.
Tavaresiella, del Guercio, 1911.
Therioaphis, Walker, 1870, The Zoologist p. 1999. MYZOCALLIS.
Thomasia, Wilson, 1910, Canad. Ent. 42:386. THOMASINIELLULA.
THOMASIN[illegible]ULA, Strand, 1917, Arch. Naturg. 82:82.
n.n. fc. *Thomasia*, Wilson, 1910.
Neothomasia, Baker, 1920.
THORACAPHIS, van der Goot, 1916, Con't. Faune Ind. Néerl. 3:242.
THRIPSAPHIS, Gillette, 1917, Canad. Ent. 49:193.
Allaphis, Mordvilko, 1921.
Tinocallis, Matsumura, 1919, Trans. N. H. Soc. Sapporo 7:100. MYZOCALLIS.
TITANOSIPHON, Nevsky, 1928, Ent. Mitt. 17:189.
TLJA, Mordvilko, 1914, Faune de la Russie p. 73.
TODOLACHNUS, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:381.
TOXOPTERA, Koch, 1857, Die Pflanzenl. Aph. p. 253.
Ceylonia, Buckton, 1891.
TRAMA, Heyden, 1837, Mus. Senckenberg 2:293.
Rhizobius, Westwood, 1845.
Tranaphis, Walker, 1870. The Zoologist p. 1999. CHAITOPHORUS.
Trichocallis, Borner, 1930, Arch. klass. phyl. Ent. 1:127. PHYLLAPHOIDES.
TRICHORGEMA, Takahashi, 1929, Trans. N. H. Soc. Formosa 19:252.
TRICHOSIPHONIELLA, Shinji, 1929, Lansanita 1:47.
TRICHOSIPHONAPHIS, Takahashi, 1922, Proc. Ent. Soc. Washington 24:205.
TRICHOSIPHUM, Okagima, 1908, Bull. Agr. Coll. Tokio 8:23.
Trichosiphum, Pergande, 1906, Ent. News 17:206. GREENIDEA.
Trifidaphis, del Guercio, 1909, Rivista di Patol. Vegetal 3:332. GEOICA.
Trilobaphis, Theobald, 1922, Ent. Mon. Mag. 58:137. CAPITOPHORUS.
Trinacriella, del Guercio, 1913, Redia 9:169. GEOICA.
TRITOGENAPHIS, Oestlund, 1922, 19th. Rep. Sta. Ent. Minnesota p. 142.
TROITZKYA, Borner, 1930, Arch. klass. phyl. Ent. 1:160.
TRUNCAPHIS, Theobald, 1918, Entomologist 51:25.
TUBERAPHIS, Takahashi, 1933, Stylops Taxonomic Ent. 2:28.
TUBERCULATUS, Schouteden, 1906, Bull. & Ann. Ent. Soc. Belgium 50:31.
Tuberculatus, Mordvilko, 1894, Varshava U. Izviestiia 8:53. MYZOCALLIS.
Tuberculoides, van der Goot, 1915, Zur Kennt. Holl. Blattl. p. 312. MYZOCALLIS.
Tuberocallis, Nevsky, 1929, Zool. Anz. 82:221. MYZOCALLIS.
TUBEROCEPHALUS, Shinji, 1929, Lansania 1:40.
TUBEROCORPUS, Shinji, 1929, Lansania 1:48.
Tuberodryobius, Das, 1918, Mem. Ind. Mus. 6:259. LACHNUS.
Tuberolachnus, Mordvilko, 1908, Ann. Mus. Zool. Imp. Acad. Sci. St. Petersburg 13:374. CINARA.
Tuberosiphum, Shinji, 1922, Dobuts. Zasshi 34:789. MEGOURA.
Tullgrenia, van der Goot, 1912, Tijdschr. Ent. 55:96. GEOICA.

TURANAPHIS, Mordvilko, 1914, Faune de la Russie p. 66.
Tychea, Koch, 1857, Die Pflanzenl. Aph. p. 296. PEMPHIGUS.
Tychea, Passerini, 1860, Gli Afidi p. 30. GEOICA.
Tycheoides, Schouteden, 1906, Bull. & Ann. Ent. Soc. Belgium 50:194. GEOICA. (n.n. for *Tychea*, Passerini.)
UNILACHNUS, Wilson, 1919, Ent. News 30:5.
UNIPTERUS, Hall, 1932, Stylops Taxonomic Ent. 1:50.
Uraphis, del Guercio, 1907, Redia 4:192. APHIS.
Vacuna, Heyden, 1837, Mus. Senckenberg 2:289. THELAXES.
Vesiculaphis, del Guercio, 1911, Redia 7:463. CAPITOPHORUS.
Watabura, Matsumura, 1917, Essays Nawa p. 89. DRYOPEIA.
Wilsonia, Baker, 1919, Canad. Ent. 51:211. NEOCHMOSIS.
Xerobion, Nevsky, 1928, Acta Univ. Asiae Mediae 8:3. ANURAPHIS
Xerophilaphis, Nevsky, 1928, Acta Univ. Asiae Mediae 8:3. PERGANDEIDA.
YAMATAPHIS, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:412.
YAMATOCALLIS, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:366.
Yezabura, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:392. ANURAPHIS.
YEZAPHIS, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:411.
Yezocallis, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:369. SYMYDOBIUS.
Yezosiphum, Matsumura, 1917, Jour. Coll. Agr. Sapporo 7:7. PERGANDEIDA.

BIBLIOGRAPHY OF PREVIOUSLY PUBLISHED CHECK LISTS

BAKER, A. C. 1920—Generic classification of the Hemipterous family Aphididae. U. S. Dept. Agr. Bull. **826**:1-109.

BÖRNER, C. 1930—Beiträge zu einem neuen System der Blattläuse. Arch. klass. phyl. Ent. **1**(2):115-194.

KIRKALDY, G. W. 1905—Catalogue of the Genera of the Hemipterous family Aphidae, with their typical species, together with a list of the species described as new from 1885 to 1905. Canadian Ent. **37**:414-420; **38**:9-18.

———1906(a)—Catalogue of the Genera of the Hemipterous family Aphidae.—Supplement. Canadian Ent. **38**:135.

———1906(b)—Catalogue of the Genera of the Hemipterous family Aphidae.—Second Supplement. Canadian Ent. **38**:202.

———1908—Third Supplement to the "Catalogue of Aphidae." Canadian Ent. **40**:80.

TAKAHASHI, RYOICHI. 1930—List of Aphid genera proposed as new in recent years. Proc. Ent. Soc. Washington **32**:1-24.

WALSH, B. D. 1862—On the genera of Aphididae found in the United States. Proc. Ent. Soc. Philadelphia **1**:294-311.

WILSON, H. F. 1910—Key to genera and notes on synonomy in the sub-family, Callipterinae. Canadian Ent. **42**:253-59.

———1911—Notes on synonomy of genera of the tribe Lachnini. Ann. Ent. Soc. Amer. **4**:51-54.

HARTWICK COLLEGE.
ONEONTA, N. Y.

The Life-history and Habits of the Digger-wasp Ammobia pennsylvanica (Linn.)

John A. Frisch, S.J.

Introduction and Nomenclature

Peter Collinson (1749) reported to the Royal Society of London the habits of the "Great Black Wasp" of Pennsylvania, as communicated to him by John Bartram of Philadelphia. The drawings of the wasp and of her "large green grasshoppers" leave little doubt that they represent *Ammobia pennsylvanica* and her katydids, the first solitary digger-wasp of America to have its habits described. Linnaeus (1767) named her *Sphex pennsylvanicus* and with the exception of Fabricius (1804), who named her *Pepsis pennsylvanica,* all other taxonomists down to 1907 retained Linnaeus' designation. Since then the name has undergone the following changes; Fernald (1907), *Chlorion (Proterosphex) pennsylvanicum;* Rohwer (1911), *Ammobia pennsylvanica;* Fernald (1931), *Chlorion (Ammobia) pennsylvanicum.* Rohwer's designation is retained here because *Ammobia* is regarded as a genus. Fernald's 1907 paper gives a list of taxonomic references.

Apart from a popular account, based on my observations and records, no detailed report of the life-history of this wasp has been published. Being a close relative of *Ammobia ichneumonea,* whose life-history was recently described in this journal (Frisch 1937), its habits are very similar and only those features in which it differs from its relative will be reported here.

Description and Distribution

Ammobia pennsylvanica is more robust and larger than *Ammobia ichneumonea,* the females measuring from 25 to 34 mm. in length and the males from 19 to 28 mm. The entire insect is colored a jet black, even the hairs being black. Pubescence is generally absent, but when present is silvery. The wings are strongly fuliginous with a bluish or violet reflection.

According to Fernald (1907) the wasp is quite common in the United States throughout the Upper and Lower Austral life zones. The most northern localities from which he has seen specimens are Durham, New Hampshire; Malden and Amherst, Massachusetts; New York, Indiana, Michigan, and Minnesota. From these States it is generally distributed to Georgia and Texas. In the West he has seen examples from Folsam and Eldorado counties, California, and from Fort Lupton, Colorado.

The Annual Cycle

At Woodstock College, Woodstock, Maryland, *Ammobia pennsylvanica* arrived one or two weeks after *Ammobia ichneumonea,* in the early part of

July, and an occasional individual was found at work as late as the first week in October.

Nesting Sites

All nests, with the exception of four, were located in two greenhouses facing one another on the north and south sides of a garden walk. The four nests were outside, in the immediate vicinity of the greenhouses. The north house was built into an embankment and its north and part of its side walls formed a retaining wall, consisting of uncemented granite blocks. The floor in both houses was the original soil, except that in a portion of the south house, a former brick floor, below the general level, had been covered by 3 to 4 inches of soil. Most of the plants had been removed to the surrounding garden plots and the floors were littered with flower pots, buckets and the other paraphernalia of a greenhouse, and with clumps of soil and roots. At the height of the season about 50 wasps were operating in each house. Though *Ammobia ichneumonea* was building nests on the slopes of the embankment, within two feet of the walls of the north house, and on several other sites only 50 feet away, not a single individual invaded the greenhouses.

The nests were built in all parts of the floors, but usually at the edges of the clumps of roots or flower pots and other objects on the floor, the tunnel extending beneath these objects. In the north house many of the nests were built in the chinks between the rocks of the retaining walls.

The Nest

The entrance tunnel was 3/4" in diameter. The excavated soil did not form a mound in front of the entrance as it does in *ichneumonea* nests, but was well scattered, often over an area a foot and more in diameter.

Also contrary to what I observed in *ichneumonea,* in which the construction of the nests was almost identical except for the number of cells, the nests of *pennsylvanica* varied greatly. The entrance tunnel was seldom straight. It would descend at an angle of about 45 to 55 degrees for 4 to 6 inches, then turn to the right or left for several inches usually still descending, turn once or twice more and end in an oval cell, 2 1/4 x 3/4 inches in diameter, 12 to 18 inches below the surface. The turns and the depths made it very difficult to reconstruct the arrangement of the cells and to count the number.

In one instance (nest 3) the wasp built her nest in the soil covering the original brick flooring. Here the tunnel descended for 3 inches to the brick floor, then followed along the floor for six inches and ended in a cell. Ten other cells, radiating from the descending shaft and connected with it by tunnels varying in length from 6 inches to 15 inches were located. These connecting tunnels were all packed tightly with soil. The shallow depth of this nest was evidently due to the brick flooring. It is difficult to say what the arrangement of these cells would have been if the brick flooring had not intervened. It is possible that *pennsylvanica* uses the same fundamental plan of *ichneumonea,* a descending tunnel from which the nests radiate on the same

level by connecting tunnels; but the length of the descending tunnel and of the connecting tunnels evidently varies considerably in *pennsylvanica*. The study of deeper nests suggests the possibility that the cells are built at different levels of the entrance tunnel.

Number of Cells

Nest 3 contained the largest number of cells, 11 in all. Three of them contained eggs, 3 newly hatched larvae and 5 contained older larvae of varying sizes. All other excavated nests, most of them over a foot below the surface, contained at most 3 cells. In view of the fact that some of the connecting cell-tunnels in Nest 3 were from 12 to 15 inches long, it is quite likely that many of the cells of the deep nests were not uncovered.

The Prey

The common prey was the katydid *Microcentrum rhombifolium (Microcentrum laurifolium)*. With some exceptions only the adult form was used. Only 6 of the 300 odd paralyzed katydids observed were *Phaneroptera furcata (Scudderia furcata)*. From 2 to 6 individuals, an average of 3.5 for 50 cells, were stored in each cell. Though the katydids weighed nearly three times as much as the wasp, the latter managed to fly with them, usually entering the greenhouse through the open upper ventilating lights. The distinct whine of the vibrating wings, audible at a distance of 20 feet and more, indicated the effort expended in the portage.

It was evidently difficult for the wasp to alter the course of her flight on short notice. Repeatedly, burdened wasps crashed into me when I was on the line of flight to their burrow. At such times they always dropped their prey and abandoned it.

The wasps, whose entrance tunnels were in the crevices between the rocks of the retaining walls, more often than not dropped their prey in attempting the difficult feat of landing on the vertical wall and then entering their tunnel with the dangling, long-legged katydid. Never once did I see an attempt made to recover the lost prey. Instead the wasps returned to their hunting almost immediately. This fact afforded an opportunity of testing the wasp's ability as a huntress. Three of the tunnels in the retaining wall, all within a radius of one foot, were plugged tightly. Five days later, a total of 252 katydids had been brought in and dropped by these wasps, an average of 16.8 katydids per wasp per day, a monument to the wasp's stupidity as well as to her prowess as a huntress.

Stinging and Condition of Paralyzed Katydids

The application of decolorized SO_2 to the ventral surface of the neck and thorax of the katydids (Frisch 1937), revealed that *pennsylvanica's* method of paralyzing was identical with that of *ichneumonea*, one stab in the neck and two in the thorax. As taken from the wasp, the katydids were completely immobilized, except for the pulsation of the abdomen and slow movements of

the mouth parts, especially the palps, and an occasional gentle waving of an antenna. After 2 or more hours there was a partial recovery from the shock of the poison, as evidenced by occasional leg movements or flexing of the abdomen, especially upon mechanical stimulation. An occasional individual could jerk its hind legs rather forcibly and move the head slowly from side to side, or up and down.

Tests showed that paralyzed katydids placed in shell vials passed faeces during 5 to 8 days, and survived from 8 to 16 days. They remained fresh from 2 to 3 days longer.

Storing the Prey

Ammobia ichneumonea always, with the possible exception of a single instance, deposits her prey on the mound of the entrance tunnel and descends into the nest for an inspection. *Ammobia pennsylvanica* apparently is not so methodical, for I have seen her take her prey down directly without a preliminary inspection. The loss of a good part of their booty by the wasps nesting in the vertical retaining wall, as mentioned above, might be explained partly by the survival of this instinct to first inspect the nest before taking the prey down.

Egg, Larva, Cocoon

The egg measured between 5 and 6 mm. in length and 1 mm. in width. It was glued to the ventral surface of the thorax in the median line between the first and second pair of legs in such a manner that it stood on end and projected out straight from the body. In *ichneumonea* the egg lies transversely across the thorax. Hatching occurred between 48 and 72 hours.

On September 11 a cell was found containing only two katydids, one carrying a newly hatched larva, and the other a two day old larva. On September 14, a similar cell was found, each victim carrying a larva approximately three days old. On September 16 a similar cell contained two newly hatched larvae.

In the study of *Ammoebia ichneumonea* one cell was found which contained three grasshoppers, the first and last one carrying an egg. This cell was found on September 16.

The dates on which these cells with two eggs or larvae were found suggest an explanation for these apparent mistakes of the wasps. My observations indicate that the wasp usually lays one egg a day. The approaching close of the season may necessitate a more rapid rate of laying of the eggs still in the ovaries. However, my observations also show that the wasps are much less successful in their hunting at this time of the season. During August they capture one victim every half hour or hour of hunting; during the middle of September they often capture only one victim a day. Thus the wasp will lay an egg on the first victim placed in the cell and then hunt for others with which to provision the cell. If she is unsuccessful for a whole day or more,

the laying of an egg on the next victim placed in the cell may be a biological necessity.

The cells of September 14 and 16 do not definitely indicate a difference in the ages of the eggs and the larvae; a day's difference in age would not be recognizable. But the larvae of cell 11 clearly indicate an age difference and confirm the opinion that the wasp's mistake is due to a biological necessity.

The larval period lasted 10 days. Mature larvae measured from 3.0-3.5 cm. in length and 0.7-1.0 cm. in width. The larvae readily ate the paralyzed grasshoppers of *ichneumonea,* after eating their own supply of katydids.

The larger cocoons measured 3.2 x 1.2 cm. Destruction of a portion of the scaffolding of the cocoon during the early stages of weaving always resulted in defective construction in the form of bulges or thin areas or in a change of the position of the cocoon within the cell.

Parasites and Hyperparasites

The following parasites have been collected from the cells of the wasp: *Senotainea trilineata* (V.d.W.), (det. A. B. Gahan), both as larvae and as pupae; *Apiochaeta* sp. (det. C. T. Greene) as pupae; *Perilampus* n. sp. and *Perilampus hyalinus* (Say), (det. A. B. Gahan), both as secondary parasites on *Senotainea trilineata; Brachymeria* n. sp. (det. A. B. Gahan), as secondary parasite on an unidentified Sarcophagid.

Another parasite, *Dibrachys* n. sp. (det. A. B. Gahan), both male and female, emerged in large numbers on March 25 from cocoons collected the previous fall, September 14.

REFERENCES

COLLINSON, PETER. 1749—Phil. Trans. Roy. Soc. London, Dec. 21.

FABRICIUS, J. H. 1775—Syst. Ent.: 346.

FERNALD, H. 1907—The digger wasps of North America and the West Indies belonging to the sub-family Chlorioninae. Proc. U. S. Nat. Mus. **31**:405.

———1931—Notes on some American Specinae. Ann. Ent. Soc. Amer. **24**:442.

FRISCH, S.J., J. A. 1937—The life-history and habits of the digger-wasp Ammobia ichneumonea (Linn.) Amer. Mid. Nat. **18**(6):1043-1062.

LINNAEUS, CARL. 1767—Syst. Nat., 12th ed., **1**:941.

ROHWER, S. A. 1911—Two new names of specoid wasps. Psyche **18**:153.

CANISIUS COLLEGE,
BUFFALO, N. Y

A New Ant from Idaho's Semidesert

A. C. Cole, Jr.

Myrmecocystus hammettensis sp. nov.

Holotype, worker major. (Cole collection No. C. I. 1000)

Total length, 4.0 mm.

Head, excluding mandibles, slightly longer than broad, somewhat broader behind than in front, with broadly rounded lateral borders and posterior corners but almost straight median occipital border. Eyes moderately convex, ovoid, more than half as long as the genae. Ocelli distinct. Mandibles broad, stout, 7-toothed, with the apical tooth longest and somewhat curved. Gula slightly concave. Clypeus convex, ecarinate, flattened and depressed on the sides, its anterior border produced outward in the middle. Frontal area distinct, only slightly depressed, not sharply angular at the apex. Frontal furrow distinct and extending back to median ocellus, but more pronounced near frontal area. Antennae slender; scapes extending about 2/5 their length beyond posterior border of the head, slightly curved and gradually thickened from base to apex; funicular joints long and narrow, first nearly as long as next two taken together, second shorter than any other and more constricted at the base, terminal joint shorter than the two preceding joints taken together and tapered at the tip.

Pronotum as broad as long; promesonotal suture broadly but only slightly impressed. Mesoepinotal constriction broad and very shallow. Epinotum about as long as high, with subequal dorsal surface and declivity; bluntly angular. Scale of petiole low, half as broad as epinotum; base but little broader than apex; inclined forward; in lateral profile cuneate; posterior surface faintly concave, anterior surface feebly convex; blunt superior border, which when seen from behind is entire. Ventral surface of peduncle produced rather sharply upward at about two-thirds the distance between the epinotum and the gaster. Thus it appears as a large, rounded lobe, with a long anterior declivity and a sharp posterior ascent. Legs long; femora stout, tibiae and tarsi slender. Gaster small, rather slender and somewhat pointed behind.

Mandibles subopaque, densely and rather coarsely striated. Clypeus and head very smoothly shining. Thorax, (except epinotum) petiole and gaster sub-opaque; epinotum smooth and shining. Entire body finely shagreened.

Hairs yellow, short, erect, delicate and pointed; abundant on scapes, head, terminal segments of maxillary palpi, thoracic dorsum, legs and gaster; more delicate on gaster; very sparse on petiole. Eyes hairy. Pubescense silvery, long and dense on thorax (except epinotum), coxae and basal segments of gaster; short, indistinct and very sparse on head. Gular ammochaetae long and conspicuous.

Blackish brown No. 1;* mandibles, eyes, lateral margins of clypeus, antennae, tibiae and tarsi pale brown; palpi dusky yellow. Basal segments of gaster with a silvery appearance because of the dense pubescence.

Paratype, worker minor. (Cole collection No. C. I. 1000.)

Total length, 2.2 mm.

Essentially like the worker major except: Eyes, antennal funiculi and tarsi lighter in color; and pubescence on thorax, femora and gaster more dense, completely covering the surface so that the parts appear very opaque.

Paratype, female (Cole collection No. C. I. 1000.)

Total length, 8.0 mm. (excluding wings. Length of wings, 10.0 mm.)

Body broad and rather stout. Head, excluding mandibles, rectangular; broader than long, slightly narrower in front than behind, with almost straight lateral borders and feebly convex posterior border. Eyes slightly larger and rounder than those of worker. Ocelli prominent. Mandibles very broad, with four prominent teeth; apical tooth extremely long and sharply pointed, other teeth much shorter and blunter, basal teeth small. Length of frontal furrow less than two-thirds the distance from frontal area to median ocellus. Frontal area very indistinct. Funicular joints 8-10 of antennae shorter and thicker than preceding joints; terminal joint tapered but with a rather blunt tip.

Thorax much broader than the head. Scutum broader than long; anterior border of scutellum slightly arcuate, posterior border strongly convex; lateral projections blunt and rather broad. Metanotum narrow and extending across thoracic dorsum. Declivity of epinotum long, flat and rather steep, forming a rather abrupt curve with the short dorsal surface. Petiole low, sharply inclined forward, much thicker at base than at apex when viewed in lateral profile, its superior border rather sharp, deeply and broadly excised in the middle; lateral margins produced outward to form at the center of each a rather sharp point; scale when viewed from behind is a four-pointed figure with a rounded base. Legs shorter and stouter than those of the holotype. Gaster large, elliptical, somewhat flattened dorso-ventrally.

Entire body shining, especially the scutum because of the absence of pubescence. Clypeus faintly striatopunctate; mandibles rather coarsely and longitudinally striate.

Hair longer and finer than in worker. Eyes and petiole more hairy than those of worker, thoracic dorsum and gaster much less so. Pubescence shorter and sparser than in worker; absent from scutum. Gaster finely shagreened.

Head and thorax black; mandibles, palpi, ocelli, lateral margins of clypeus, antennae and legs pale brown; mandibular teeth dark brown. Gaster blackish-brown No. 1.

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* Colors were compared with the plates in, "Color Standards and Color Nomenclature," by Robert Ridgway. Comparisons were made without magnification. Colors designated for the smaller structures (mandibles, palpi, etc.) are the author's conception and were determined under a magnification of 30 diameters.

Paratype, male. (Cole collection No. C. I. 1000.)
Total length, 3.1 mm.

Head small, excluding mandibles and eyes a little longer than broad; narrower below than above; posterior border broadly convex, with rounded posterior corners; genae slightly concave. Eyes very convex, protruding from the sides of the head a distance equal to that between the antennal fossae. Ocelli large, set high on the occiput so that the lateral ocelli break the contour of the upper border of the head when viewed from in front. Mandibles less than twice as broad at the apex as at the base, outer borders convex, inner borders almost straight; with a rather small and sharp apical tooth and two small, blunt, basal teeth. Clypeus convex, impressed laterally, its anterior border almost straight. Frontal area broadly angular, only sightly impressed. Frontal groove faint except at apex of frontal area and just below the median ocellus where it is impressed to form a shallow but rather broad pit. Antennal grooves distinct and broad, extending posteriorly about half the distance between the antennal fossae and the median ocellus. Antennae slender; length of scapes slightly less than the distance between the outer lateral margins of the eyes; first funicular joint short, enlarged distally; remaining joints narrower, subequal and cylindrical; terminal joint longer and tapered.

Thorax only slightly broader than head, including eyes; robust, shaped somewhat like that of the female. Scutum of mesonotum very convex anteriorly, with a gradual declivous surface posteriorly, forming a broad but distinct impression at juncture with mesonotum. Sides of scutellum greatly impressed, so that the apical surface, when viewed from above, is broadly triangular; its anterior border rather straight, posterior border strongly convex; lateral projections broad and rather blunt. Metanotum and epinotum similar to those of female. Petiole as in worker, but superior border of scale sharper and with a shallow impression, and without the prominent lobe on the ventral surface. Legs long and rather slender, with large claws and pulvilli. Wings large; cell M 4 absent. Gaster small and narrow.

Pubescence and pilosity as in major worker, except pubescence much less abundant on thorax and gaster, giving this sex a more shining appearance throughout. Pubescence dense on the legs. Basal segments of gaster lack the silvery appearance of the major worker, but are more pubescent than the other segments. Scutellum and mesothoracic parapteron glossy because of absence of pubescence and presence of only very few hairs. Hairs longer and more slender than those of worker. Antennae with very dense subappressed hairs; some on scapes are erect.

Head, scutum of mesonotum and scutellum glossy chaetura black; mandibles, antennae, lateral margins of clypeus, maxillary palpi, pronotum, legs and everything posterior to scutellum blackish-brown No. 1. Eyes, ocelli and genitalia much lighter. With a magnification of 30 diameters, the blackish-brown structures appear dark reddish-brown.

Paratype, replete (Cole collection No. C. I. 1000.)
Differing from the major worker only in the enormous distention of the gaster which is about the size of a pea.

Types were selected from a large series of specimens collected by the author from minute crater mounds of sand, 8-15 cm. in diameter, on a plain of mixed *Artemisia tridentata* Nutt. and *Bromus tectorum* L. at Hammett, Idaho, May 30, 1932. Hammett is a very small village just south of Mountain Home, on the federal highway between Twin Falls and Boise. The mounds were just opposite the store and on the north side of a road leading westward to Indian Cove. The colonies were populous, but not numerous, and were aggregated in an "open" area of only a few square yards. Brood chambers and those containing males and females were two to three feet below the soil surface. Repletes were found in the nests. Topotypes were collected during the summers of 1933 and 1934.

Variation in paratype material.—The workers vary from 2.2 to 5.0 mm. in length. The minor workers show the same characteristics as the one selected to represent the series. The major workers vary from the holotype only slightly. In a few the color has more of a reddish cast, and some specimens have the tips of the antennal funiculi infuscated. In the paratype series of four females one of the specimens has a reddish cast to the scutellum, and the gaster is a lighter brown. In this specimen, also, the hairs on the head are reddish while those on the rest of the body are yellow. The males also show little variation. A few specimens have a lesser quantity of pubescence on the epinotum, so that the declivity is more shining; others have a shallower impression in the superior border of the petioler node than does the paratype used for the description. Several males have only a broad apical mandibular tooth without other teeth, while a few show vestages of basal teeth.

Affinities.—M. hammettensis is undoubtedly a species distinct from *M. yuma* Wheeler. The worker is similar to that of *yuma* especially in size, color, general shape of the head and structure of the petiole. It differs from it, however, and from the variety *flaviceps* Wheeler, in the following respects: (1) Gula slightly concave; (2) ocelli distinct; (3) mandibles coarsely striated; (4) erect hairs on antennal scapes very abundant; and (5) pubescence long and dense on thorax. It is similar to *M. lugubris* Wheeler, from California, in size, contour of the gula and the coarsely striated mandibles; but differs from it by the presence of erect hairs on the antennal scapes and by the shape of the petiole which, in *hammettensis*, is more blunt and lacks an impression in its superior border. No comparisons of the sexes can be made with those of *yuma* and its var. *flavipes* or with *lugubris*, since to my knowledge, those of the latter have not been described.

The holotype and a long series of paratypes are in the author's collection. Paratypes and topotypes are to be deposited in the U. S. National Museum, the American Museum of Natural History, and in the collections of C. H. Kennedy (Ohio), W. S. Creighton (N. Y.), Neal A. Weber (S.D.), and Arnold Mallis (California). Metatypes are in the collection of the U. S. Bureau of Entomology and Plant Quarantine, Twin Falls, Idaho.

DEPT. OF ENTOMOLOGY,
UNIVERSITY OF TENNESSEE,
KNOXVILLE, TENN.

The Size of Certain Naiades from Western Lake Erie in Relation to Shoal Exposure

C. J. D. Brown, Clarence Clark and Bruce Gleissner

Introduction

The variability of shell characters in fresh-water mussels, particularly those of size, shape and color, has received attention from a considerable number of malacologists. Since many taxonomists in the group have relied entirely upon these characters for specific and varietal designations, investigations into their significance are of importance. During July and August of 1937, three ecologically distinct habitats were studied in the island area of western Lake Erie, in an attempt to correlate, if possible, the limnological factors operating in these habitats, with the size of certain mussels living there. More than 1000 specimens were collected. These were represented by 24 species, eight of which were present in large enough numbers to be of value in our measurements.

According to Walker (1913) the naiad fauna of Lake Erie is of recent origin. He states ". . . that the peculiar fauna now characterisitc of Lake Erie is the result of the modification from environmental causes of post-glacial emigrants from the south and not the result of any survival in that region of any part of the preglacial fauna." Generally speaking, Lake Erie has been accredited with one of the most stunted and depauperate faunae yet studied. Such conclusions are undoubtedly based upon collections from the more exposed areas of the lake. Ortmann (1919) points out that individuals of certain species from Lake Erie are larger than those from the Ohio River. He recognized most of the varietal names of other workers but repeatedly called attention to the almost universal intergradation between the so-called lake and stream forms. Grier (1920) claims to have shown significant differences between the measurements of streams and lake varieties, which is somewhat doubtful since he failed to consider the variation within the lake itself and since he admits having selected his material from museum specimens. He writes as follows: "A careful selection was first made of the material on hand to eliminate all stunted or otherwise abnormal specimens." He likewise fails to take into account the variation which might have been the result of age rather than location.

Considerable attention has been given studies involving the relation of size and shape in mussels to their environmental location in streams. Ortmann (1920), Ball (1922) and Baker (1927) have shown that, for several species of mussels, individuals are more obese in the lower parts of streams than in the tributaries and upper waters. Van der Schalie (1938) found that obesity was proportional to the size of the stream in *Alasmidonta calceolus* but also shows complete intergradation between specimens from varied habitats. Grier and Mueller (1926) claim conflicting evidence to the "law of stream distribu-

tion" from their studies on the Mississippi River. Altnöder (1926) has shown that the height-length relationship in *Margaritana margaritifera* is correlated with gradient, also that this species grows more rapidly in the down-stream portions.

Certain literature has appeared before us pertaining to comparative habitat studies in lakes and the effect of environment on the size and shape of fresh-water mussels. Headlee and Simonton (1904) and Headlee (1906) noted differences of color, weight and size in *Anodonta* and *Lampsilis* from Winona Lake. The straw-colored lighter variety of *Lampsilis siliquoidea* was found more abundantly near shore on chara-covered bottoms. The darker, heavier variety was more abundant in the deeper water on sand and gravel beds. Many intergrades were found in both shallow and deep water and on all kinds of shoal. Allen (1922) suggests that the type of bottom is the most important factor in distribution of fresh-water mussels in a lake and considers wave action of very little importance. *Lampsilis siliquoidea* was found to become progressively smaller from one end to the other in Lake Maxinkuckee (Evermann and Clark 1918). These same workers found separate forms of this species in Lake Maxinkuckee and Lost Lake but found complete integradation between the two. They explain this condition as a difference in "breed." Certain studies on the snail *Goniobasis livescens* (Wiebe, 1926) show that obesity is directly proportional to the degree of exposure and that this species is most abundant (Krecker, 1924) in protected waters. Baker (1916) calls attention to the fact that while snails are often limited due to wave action, clams seldom are. Shells of *Thais lapillus* collected from the exposed coast were small and thin (Colton, 1922) while those from sheltered bays were large and strong.

Materials and Methods

The lake level was considerably higher during the summer of 1937 than in the two previous years and as a result mussels were located in rather deep water (1.5-5 meters). Because of high turbidity a standard Secchi disc could not be seen at a depth of more than 125 cm. at any station. The combination of these two conditions made collecting somewhat difficult as all specimens had to be located blindly. A collection taken in this manner, however, had some added value since it was random in nature and represented, more or less, the existing ratio between the different species and the age groups of each species.

Collections were made in one of the following ways: Mussels were located by walking barefoot over the bottom and collected by means of a semicircular dip net; or by diving; or by means of two long handled rakes fitted together as tongs. A crowfoot dredge of the type used in river "clamming" seemed to be of little use in the areas studied. The soft parts were removed from the shells soon after collections were made. All of the shells were brushed, thoroughly washed and dried at a room temperature of 25-28° C. for at least forty-eight hours before measurements and weights were taken. We are indebted to Dr. Henry Van der Schalie for carefully checking our identifications and for the many helpful suggestions he has given us.

No specimens were discarded. The entire lot of each species was measured and weighed. The lengths (Fig. 1) were taken by means of a measuring

board fitted with a fixed millimeter scale along one side. A short T-square run along this scale was used to find the total, anterior and posterior lengths. Height and obesity were measured with a "Helios" vernier caliper of the conventional type. Both valves of each mussel were weighed to the nearest tenth of a gram by the use of an "Ohaus" scale (made by the Newark Scale Works Inc.). Age was determined by counting the number of growth lines. According to Isely (1914) these are sufficiently regular to be reliable in age determination. A strong electric light (method described by Chamberlain, 1931) mounted in a reflector was used to help determine the number of bands in a few instances.

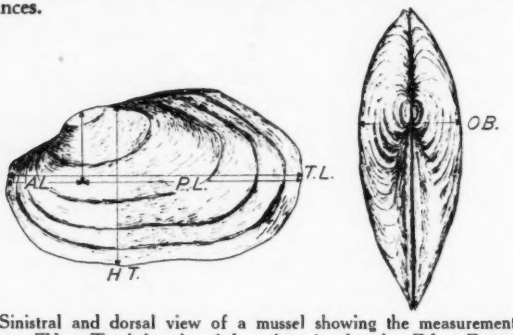


Fig. 1. Sinistral and dorsal view of a mussel showing the measurements taken on each specimen. T.L.—Total length; A.L.—Anterior length; P.L.—Posterior length; HT.—Height; OB.—Obesity.

Ortmann (1919) and Grier (1920) point out the fact that lake species show more regular and distinct bands than do the same species in streams. We experienced little difficulty in counting these rings when the number was less than ten or twelve; however, we do not have as much confidence in certain of our determinations on older specimens. For the purposes of this paper each distinct band is taken to represent a year. The writers are aware that certain bands might be the result of some unfavorable conditions aside from the winter mark of growth arrest. Such irregularities as undoubtedly appear at times may account in part for certain unexplained discrepancies between size and age that are found in some of our older specimens.

No attempt was made to distinguish between sexes. It is true that secondary sex characters are often exhibited as modifications of size and shape of the shell in certain species, e.g., the shorter total length and the increased obesity in the female of *Lampsilis siloquoidea*. On the other hand we found numerous intergrades between the typical modified female type and the unmodified male of this species. In the light of the present knowledge of sex in naiads we consider it unreliable to attempt a separation of the two sexes by means of shell characters. Observations on the epidermal color differences revealed that the general density of color is proportional to the degree of exposure. Our Pelee Island specimens were much lighter than those from Fish Hatchery Bay or East Harbor. This was especially noticeable in *Lampsilis siliquoidea, L. ventricosa* and *Proptera alata*.

Description of Habitats

The great variety of ecological situations found in a body of water the size of Lake Erie furnishes an exceedingly valuable place for studies relating to the effects of physical factors upon the morphological characteristics of species. Three situations were studied. These were selected on a basis of exposure as follows (Fig. 2): East Harbor, protected; Fish Hatchery Bay, moderately exposed; Pelee Island, extremely exposed. Observations were made on the physical, chemical and biological characteristics of each habitat.

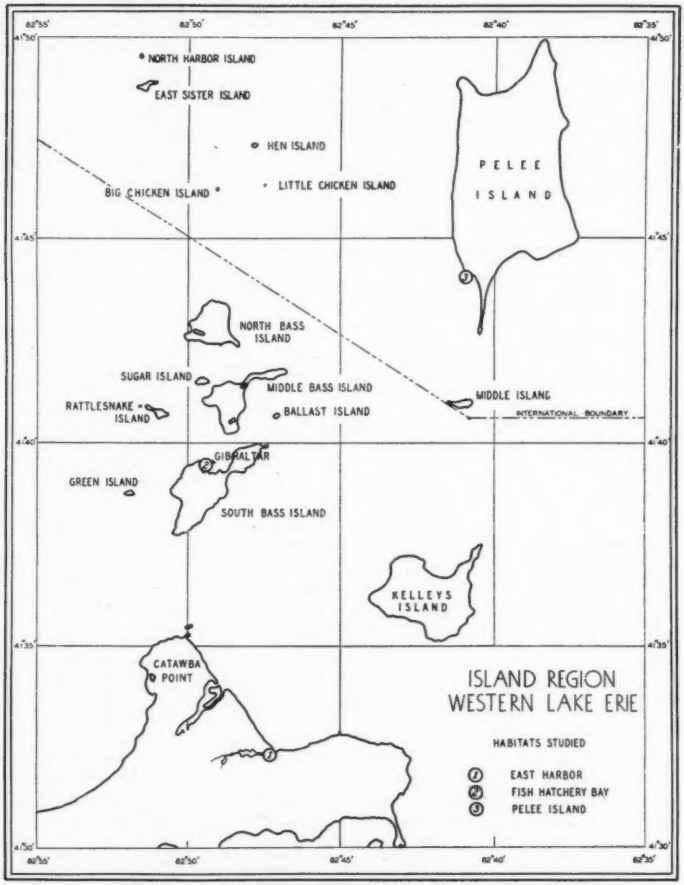


Fig. 2. Map of the island area in western Lake Erie showing the habitats studied.

East Harbor

East Harbor is located on the Marblehead peninsula (Fig. 2) and is connected with Lake Erie by a narrow channel. The portion of the channel studied lies very near the lake, just beyond its mouth and has an area of about one acre. Regardless of the direction of the wind there is very little water agitation in the channel. It is, however, subject to rather regular currents in and out due to changes in the lake level (Krecker, 1931).

The bottom is composed of sand with small patches of sandy marl and organic silt mixture and is rather compact, being somewhat crusted in places. Mussels were found in water from 1-2 m. in depth. There is an abundance of marginal aquatic vegetation and several moderately dense beds of Potomageton scattered over the area. Quantitative plankton samples show it to be slightly more productive of species and numbers of individuals than the other areas studied. This conclusion, however, is based upon only one series of samples taken at each station and therefore may not represent conditions at other times during the year. A summary of certain physical and chemical analyses is given in Table 1.

Fish Hatchery Bay

This habitat is located between Gibraltar Island and the Ohio State Fish Hatchery on South Bass Island (Fig. 2). The area studied is on the Gibraltar side and is about one acre in extent.

Table 1

Chemical data for the three habitats in Lake Erie.

Habitat	Degree of Exposure	Depth of Water	Date 1937	Temp. at Bottom	O_2 ppm.	CO_2 ppm.	phth. alkalinity ppm.	methyl orange alk.ppm.	pH.
East Harbor	Very little	1-2 meters	8/10	23.5	7.2	0.0	2.0	96	7.3
Fish Hatchery Bay	Moder-ate	1-3 meters	8/5	25.0	8.1	0.0	0.0	93	7.5
Pelee Island	Very great	1-2.5 meters	8/13	24.5	7.7	0.0	2.0	95	7.2

This bay is connected to the main lake on the north and east by a channel one-eighth mile wide. Winds from the north and northeast cause considerable agitation here but it is completely protected from south and the prevailing west winds. There is considerable current crossing this shoal most of the time due to the almost ever changing level of the lake. Sometimes it is in one direction, sometimes in the other.

About 50 percent of the bottom is composed of large rubble. The intervening areas are of sand and glacial silt and are apparently very suitable places for mussels. Specimens were collected in water of 1-3 meters depth. The aquatic vegetation was rather sparse over this shoal. Small quantities of *Potamogeton, Ceratophyllum* and *Vallisneria* were observed. In the more protected part of the bay, the weed beds were very dense. Plankton was slightly less abundant than in East Harbor.

Pelee Island

This exposed habitat is located on the southwest side of Pelee Island (Fig. 2) and is of several acres in extent. It is exposed to all north, south and west winds and faces an extended area of open lake which makes it subject to violent wave action during storms. This shoal is seldom free from a certain amount of water agitation. Several living specimens of *Lampsilis siliquoidea, L. ventricosa* and *Ptychobranchus fasciolaris* were found cast up along the shore during days of only mild westerly winds. There is evidence of considerable mussel depletion due to wave action. Many dead clams (with bodies still intact) were found in the shore drift. Besides the almost ever present waves, there is considerable current (north and south) along the shore of the island.

The bottom is composed of gravel and sand. The gravel areas are nearest shore extending out 25-70 meters to a water depth of about 1.25 meters. The bottom is predominantly sand beyond this zone and supports the major mussel population. There is a complete lack of rooted vegetation. Plankton samples showed fewer species and numbers of individuals than at either of the other habitats. There is almost complete uniformity of the chemical conditions in the three places studied (Table 1).

Discussion of Species

The distribution of species throughout the various habitats in the lake is

Table 2
List of species showing the number of specimens taken in the random sample from each habitat.

Name of Species	East Harbor	Fish Hatchery Bay	Pelee Island
Fusconaia flava (Raf.)	1	4	4
Quadrula pustulosa (Lea)	0	1	0
Cyclonaias tuberculata (Raf.)	0	1	2
Amblema costata Raf.	2	6	2
Pleurobema cordatum coccineum (Con.)	1	8	0
**Elliptio dilatatus* (Raf.)	0	134	37
Strophitus rugosus (Swainson)	1	9	5
Anodonta grandis Say	6	1	3
**Ptychobranchus fasciolaris* (Raf.)	0	71	12
Obliquaria reflexa Raf.	0	1	0
**Proptera alata* (Say)	70	21	46
**Leptodea fragilis* (Raf.)	37	18	27
Obovaria subrotunda (Raf.)	1	22	2
**Ligumia nasuta* (Say)	29	5	2
**Ligumia recta* (Lamarck)	3	11	25
Micromya iris (Lea)	0	4	0
Micromya fabalis (Lea)	0	42	0
Lampsilis fasciola Raf.	0	1	0
**Lampsilis siliquoidea* (Barnes)	131	84	62
**Lampsilis ventricosa* (Barnes)	8	15	123
Truncilla donaciformis (Lea)	0	1	2
Truncilla truncata Raf.	0	1	2
Dysnomia perplexa rangiana (Lea)	0	3	0
Dysnomia triquetra (Raf.)	0	17	3

* Measurements are given for these species in the following tables.

by no means uniform. *Elliptio dilatatus,* while the most abundant species in Fish Hatchery Bay, was not found at all in East Harbor and was fourth in abundance at Pelee Island (Table 2). The distribution of *Ptychobranchus fasciolaris* is very similar to the above. *Proptera alata, Leptodea fragilis* and *Lampsilis siliquoidea* occurred in relatively large numbers at each station. *Lampsilis ventricosa* was most abundant on the more exposed shoals. *Micromya fabalis* though fourth in abundance at Fish Hatchery Bay was not found in either of the other habitats. While our list of species probably does not include all of those present at any station, it does indicate, to a certain degree, the relative density of the more abundant species.

The measurements of all species collected are not included here. Of this group, only eight were present in large enough numbers to be of use in a comparative study of size and shape. The growth rate, distribution of age groups, average size and weights are given in the tables under each species considered. It should be mentioned that while we did find a few "young of the year," they have been omitted from our tables. Many workers have described the apparent lack of young specimens. This is in all probability due not to the absence of material but rather to the difficulty encountered in its collection. The methods we used were not well suited for collecting very small specimens.

Elliptio dilatatus

(Table 3)

A random sample of 44 specimens from Fish Hatchery Bay was compared with 37 from Pelee Island and 21 from the Maumee River.

Those from the Maumee River have larger average measurements than specimens from Fish Hatchery Bay. The smallest individuals came from Pelee

TABLE 3

Size and weight averages of each age class for *Elliptio dilatatus* (measurements in millimeters; weights in grams).

No. Specimens	Age	Total Length			Av. Ant. L.	Av. Post. L.	Av. Ht.	Av. Ob.	Weight		
		Max.	Av.	Min.					Max.	Av.	Min.
Fish Hatchery Bay											
1	1		20.0		5.0	15.0	10.0	5.0		0.5	
1	2		27.0		7.0	20.0	15.0	7.0		1.2	
1	3		39.0		9.0	30.0	20.0	12.0		5.1	
2	4	47	44.5	42	10.0	34.5	23.5	15.0	11	10.0	9
4	5	56	51.0	47	12.0	39.0	25.8	17.0	18	12.9	9
5	6	59	55.4	50	12.2	43.2	27.6	18.2	19	16.5	11
4	7	68	60.8	51	13.7	47.0	31.0	20.3	30	22.8	16
7	8	81	68.9	58	13.4	55.1	34.0	22.7	48	32.0	20
6	9	81	71.2	65	14.3	56.8	34.7	24.5	59	35.3	28
3	10	77	75.0	72	14.3	60.7	35.7	23.7	40	36.2	34
6	11	79	73.0	69	13.8	59.2	36.2	25.8	49	41.1	34
3	12	81	77.3	71	13.3	64.0	37.0	26.0	49	46.2	42
Av. of 44 specimens			63.3		12.8	50.4	31.3	21.2		28.0	

					Pelee Island						
1	2		28.0		6.0	22.0	15.0	8.0		1.4	
1	3		33.0		8.0	25.0	18.0	9.0		2.5	
1	4		39.0		9.0	30.0	20.0	10.0		4.9	
1	5		45.0		8.0	37.0	23.0	14.0		9.8	
1	6		57.0		10.0	47.0	30.0	18.0		18.8	
3	8	55	53.3	50	11.0	42.0	27.0	18.0	19	16.1	13
6	9	64	58.1	51	9.2	48.8	28.0	20.0	25	20.8	16
5	10	67	57.4	46	11.0	46.2	28.6	19.4	30	21.0	11
2	11	64	55.5	47	9.0	46.5	26.5	18.0	25	17.4	10
8	12	68	61.1	54	10.6	51.5	29.1	19.9	29	22.5	15
2	13	71	64.0	57	11.0	53.0	31.0	22.0	40	30.1	20
3	14	78	66.3	52	10.7	55.7	30.3	22.0	41	30.9	18
1	15		63.0		11.0	52.0	32.0	21.0		29.8	
2	16	69	65.0	61	11.0	54.0	30.5	22.5	29	26.0	23
Av. of 37 specimens			57.2		10.1	47.2	27.8	18.9		20.7	
					Maumee River						
21 not aged		99	91.9	71	17.7	73.6	43.3	29.5	88	67.0	29

Island. Some of the differences are as follows: The average total length of Maumee River specimens is 31.1% greater than those from Fish Hatchery Bay and 37.8% greater than those from Pelee Island. The average obesity measurements are similar in that the Maumee River specimens are 28.5% greater than those from Fish Hatchery Bay and 35.9% greater than those from Pelee Island. The differences are still greater when the weights are compared. Those from the Maumee river have 58.1% greater weight than the Fish Hatchery specimens and are 70.8% heavier than those from Pelee Island. The individual variation within certain age classes for a single habitat are also large. There is a 40% difference in length and 140% in weight for the eight year old specimens from Fish Hatchery Bay. Some of the age groups from Pelee Island show even greater differences.

Our measurements do not conform to those of Grier (1918), who differentiates between *Elliptio dilatatus* (stream form) and *E. dilatatus sterkii* (lake form). He gives the height and obesity in terms of total length, for the former as 48% and 25% respectively and for the latter as 51% and 30% respectively. Ortmann distinguishes the two by indicating an obesity of less than 30% for *E. dilatatus* and an obesity of more than 30% for *E. dilatatus sterkii*. Our average measurements are: height, 47.1% and obesity 32.1% for Maumee River specimens; height 49.4% and obesity 33.5% for Fish Hatchery Bay collections; height, 48.6% and obesity 33.1% for Pelee Island specimens. According to height, all of our specimens (those from the river as well as the lake) belong to the stream variety while according to obesity they would all become *sterkii*. We seriously doubt the validity of varieties based upon such variable characters.

The five to twelve year classes were the most abundant in Fish Hatchery Bay, while those from Pelee Island were 8-13 years. The growth of this species is more rapid at first, agreeing with the observations of Isely (1914) and others. While there is a consistent difference between the size and weights of all specimens of the same age from the different habitats, the oldest individuals show the greatest differences.

Ptychobranchus fasciolaris
(Table 5)

No specimens of *Ptychobranchus fasciolaris* were found in East Harbor. Those from Fish Hatchery Bay show a 9.1% greater total length, a 7.2% greater height, a 7% greater obesity and a 19% greater weight than the ones from Pelee Island. A comparison of the stream and lake forms of Ortmann (1919) and Baker (1928) with our specimens is given in Table 4.

TABLE 4
A comparison of the measurements of *Ptychobranchus fasciolaris*.

Source of Material	No. of Specimens	Av. Length	Av. Ht.	Ht-L	Av. Obesity	Ob-L	Remarks
Baker	1	77	46	58.4	25	32.3	Type of *P. fasciolaris lacustris*
Ortmann	6	100	54	54	31	31	Selected sample from Pennsylvania streams.
Fish Hatchery Bay	35	50.5	27.8	54.9	15.8	31.3	Random sample
Pelee Island	12	45.9	25.8	53.3	14.7	31.9	Random sample
Maumee River	3	89	54	60.7	30	33.7	Only specimens collected

Baker's type of the lake form is intermediate in size between our Maumee River and Lake Erie specimens. According to the height-length relationship, it is nearest our Maumee River mussels and according to the obesity-length relationship, it is not significantly different from either Ortmann's or our specimens. Baker's type *P. fasciolaris lacustris* for the lake form is 43.4% greater than our Pelee Island average and at the same time is only 28% smaller than Ortmann's average of the stream form. It seems to us that varieties named on a basis of size variation alone have no significance in this species.

The age groups from the two Lake Erie habitats show rather uniform distribution.

TABLE 5
Size and weight averages of each age class for *Ptychobranchus fasciolaris*.

No. Specimens	Age	Total Length Max.	Total Length Av.	Total Length Min.	Av. Ant. L.	Av. Post. L.	Av. Ht.	Av. Ob.	Weight Max.	Weight Av.	Weight Min.
					Fish Hatchery Bay						
1	2		33.0		10.0	22.0	17.0	8.0		2.1	
2	3	34	33.5	33	10.0	23.5	18.5	9.5	3	3.0	3
7	4	40	37.0	34	11.6	25.4	20.4	10.9	5	4.2	3
3	6	48	45.0	43	12.3	32.7	25.3	14.0	9	8.5	8
2	7	48	46.5	45	14.0	32.5	28.0	14.0	11	10.0	9
1	8		48.0		11.0	37.0	28.0	15.0		11.9	
2	9	53	50.0	47	13.5	36.5	28.0	15.5	10	10.0	10
3	10	55	53.3	52	15.3	38.0	31.0	16.7	16	14.2	10
3	11	67	63.0	55	16.3	46.7	34.7	19.0	26	22.0	16
2	12	66	62.0	58	16.0	46.0	36.5	20.5	31	25.5	20
3	13	64	60.0	55	15.0	45.0	32.3	19.3	21	19.1	18
2	14	60	57.0	54	14.0	43.0	34.5	20.0	21	19.5	18
3	15	69	66.7	64	15.3	51.3	38.0	22.0	33	30.5	28
1	18		67.0		16.0	51.0	39.0	23.0		33.1	
Av. of 35 specimens			50.5		13.6	36.9	27.8	15.8		14.2	

					Pelee Island						
1	2		31.0		9.0	22.0	17.0	8.0		2.3	
1	3		30.0		8.0	22.0	16.0	8.0		2.1	
2	4	41	38.5	36	11.0	27.5	21.0	11.5	17	11.0	5
1	5		48.0		14.0	34.0	26.0	12.0		9.0	
2	6	48	46.5	45	13.5	33.0	27.0	15.0	13	11.0	9
1	8		51.0		13.0	38.0	28.0	15.0		12.7	
2	9	59	55.0	51	17.5	37.5	32.0	18.0	22	17.5	13
2	11	57	55.5	54	14.0	41.5	31.5	22.0	18	16.5	15
Av. of 12 specimens			45.9		13.1	32.9	25.8	14.7		11.5	
					Maumee River						
3 not aged		91	89.0	85	18.0	71.0	54.0	30.0	96	92.0	87

Proptera alata
(Table 6)

Proptera alata was fairly abundant in all the habitats studied and showed a great deal of variation in size and weight. The averge total length of East Harbor specimens is 13.8% greater than those from Fish Hatchery Bay and 40.3% greater than those from Pelee Island. The average total lengths of Ortmann's selected sample from Pennsylvania streams is 131.8 mm. as compared to 86 mm. for his Lake Erie sample. This latter group is near our Fish Hatchery Bay specimens in average size. Our East Harbor specimens are intermediate between Ortmann's stream and lake forms and our Pelee

TABLE 6
Size and weight averages of each age class for *Proptera alata*.

No. Specimens	Age	Total Length Max.	Total Length Av.	Total Length Min.	Av. Ant. L.	Av. Post. L.	Av. Ht.	Av. Ob.	Weight Max.	Weight Av.	Weight Min.
					East Harbor						
2	2	61	61.0	61	11.5	49.5	34.5	21.0	8	7.0	6
2	3	74	71.5	69	14.0	57.5	40.5	25.5	20	17.5	15
4	4	98	84.7	79	16.3	68.5	48.5	31.3	43	32.8	30
11	5	105	92.2	77	18.6	73.5	50.6	33.3	59	42.3	20
15	6	119	95.9	80	19.0	76.9	52.6	34.5	86	48.6	21
14	7	125	111.4	85	21.6	89.8	58.9	38.4	106	73.2	41
11	8	127	115.3	94	19.5	95.8	61.5	39.5	129	87.3	66
5	9	125	118.8	114	21.4	97.4	62.8	41.2	98	88.7	71
2	10	121	117.0	113	20.0	97.0	65.0	41.5	112	101.5	91
1	11		130.0		21.0	109.0	67.0	43.0		75.2	
2	12	117	113.0	109	23.0	90.0	61.0	45.5	108	93.0	78
1	14		92.0		15.0	77.0	51.0	35.0		69.6	
Av. of 70 specimens			102.3		19.3	83.0	55.4	36.2		61.9	
					Fish Hatchery Bay						
4	3	83	72.7	61	12.5	60.3	39.7	26.8	34	22.3	11
2	4	77	68.5	60	11.0	57.5	38.5	26.0	28	18.5	9
5	5	104	87.2	72	13.6	73.6	47.0	30.8	53	38.1	21
6	6	107	97.8	82	16.3	81.5	51.6	34.8	80	56.7	34
2	7	103	102.5	102	14.0	88.5	54.0	36.0	73	72.0	71
2	8	103	98.5	94	14.0	84.5	51.5	38.0	73	71.0	69
Av. of 21 specimens			88.2		14.0	74.2	47.2	31.9		44.9	

					Pelee Island						
4	2	41	38.5	35	7.3	31.2	22.3	12.5	2	2.0	2
11	3	57	50.0	43	9.2	40.9	27.9	16.5	8	5.0	2
17	4	78	64.0	54	11.6	52.6	35.4	21.7	22	14.0	9
11	5	86	71.3	60	11.7	59.5	39.3	24.2	39	21.3	11
2	6	75	75.0	75	10.5	64.5	39.0	25.5	25	24.0	23
1	9		84.0		10.0	74.0	46.0	29.0		39.7	
Av. of 46 specimens			61.1		10.6	50.6	33.8	20.6		13.6	

Island specimens are much smaller than anything yet recorded.

There is an even greater difference in weight than in size of specimens from the three habitats. Those from East Harbor are 27.5% greater than those from Fish Hatchery Bay and 78.5% greater than those from Pelee Island. There seemed to be no significant difference between the height-length and obesity-length relationships.

The distribution of age classes are as follows: The 5-8 year groups inclusive are predominant in East Harbor; the 3-5 year in the Pelee Island habitat; those from Fish Hatchery Bay show a more or less even distribution of age groups.

Leptodea fragilis

(Table 7)

A comparison of the average total lengths of all specimens from each habitat shows the largest specimens to occur in East Harbor, the next in the Maumee River, the next at Pelee Island and the smallest in Fish Hatchery Bay. This is a good example of what collections may show when age is not taken into account. When the averages of any of the age groups are compared we get an entirely different picture. The third, fourth and fifth year classes from the Maumee River and East Harbor are very similar in total lengths. Comparisons of any age class from all habitats shows the largest specimens to consistently occur in East Harbor and the Maumee River, the next largest in Fish Hatchery Bay and the Smallest at Pelee Island.

Ortmann (1919) reports that the Lake Erie form is larger and finer than those from the Ohio River drainage. His conclusions were drawn from comparing a small series of the larger specimens. Our collections of this species show the same size differences as exhibited by the other species reported here, the one possible exception being a greater difference between the East Harbor and Fish Hatchery Bay specimens. A comparison of the three year old groups shows the average total length of East Harbor specimens to be 34.7% greater than those from Fish Hatchery Bay and 44.2% greater than those from Pelee Island. Our Maumee specimens are much heavier for their size than those from East Harbor.

The distribution of age classes is as follows: 3-6 year groups predominate in East Harbor; 1-4 in Fish Hatchery Bay; 2-6 at Pelee Island and the 2-3 in the Maumee River. Very erroneous comparisons may be made when age is not taken into consideration.

TABLE 7

Size and weight averages of each age class for *Leptodea fragilis*.

No. Specimens	Age	Total Length Max.	Total Length Av.	Total Length Min.	Av. Ant. L.	Av. Post. L.	Av. Ht.	Av. Ob.	Weight Max.	Weight Av.	Weight Min.
					East Harbor						
1	2		77.0		17.0	60.0	40.0	24.0		9.0	
6	3	111	104.8	100	23.2	81.7	57.3	34.0	31	27.8	25
11	4	122	113.2	102	25.3	87.9	60.3	36.4	54	38.9	22
11	5	124	119.4	113	27.4	91.3	64.4	38.6	55	46.6	35
6	6	132	122.0	111	27.2	94.8	65.2	39.0	69	52.5	39
2	7	141	129.5	118	29.5	100.0	69.0	41.5	81	60.0	39
Av. of 37 specimens			115.0		25.9	88.9	61.7	37.1		41.9	
					Fish Hatchery Bay						
4	1	41	30.0	21	6.3	23.7	16.0	8.5	2	0.9	0.3
1	2		53.0		11.0	42.0	27.0	18.0		3.0	
5	3	75	68.4	60	13.2	55.2	36.2	24.8	11	8.4	5
5	4	93	87.8	82	17.0	70.8	47.0	30.8	26	21.2	17
1	5		98.0		18.0	80.0	50.0	32.0		31.3	
1	6		103.0		21.0	82.0	66.0	35.0		38.0	
1	12		111.0		23.0	88.0	66.0	41.0		66.9	
Av. of 18 specimens			70.3		13.8	56.5	38.3	24.3		16.2	
					Pelee Island						
3	2	50	41.6	32	9.7	32.0	23.3	13.3	4	2.3	1
4	3	63	58.5	52	12.0	46.5	31.8	19.5	7	5.8	4
9	4	82	73.7	64	14.8	58.9	39.9	23.5	22	14.0	7
3	5	85	81.7	78	17.0	64.7	46.0	27.0	27	21.2	17
3	6	106	86.3	65	16.0	70.3	45.3	30.6	46	26.0	9
1	7		91.0		16.0	75.0	48.0	30.0		29.0	
2	8	102	100.0	98	23.0	82.0	53.0	35.0	43	36.5	30
2	9	109	101.0	93	13.5	87.5	52.5	33.0	50	40.5	31
Av. of 27 specimens			74.3		14.7	60.4	40.3	24.8		17.8	
					Maumee River						
16	2	124	92.0	71	25.6	66.7	53.7	32.3	55	29.5	13
12	3	120	103.8	81	28.7	76.0	60.8	36.3	88	44.5	24
1	4		106.0		30.0	76.0	60.0	38.0		41.9	
1	5		123.0		37.0	86.0	77.0	45.0		75.4	
Av. of 30 specimens			98.2		27.3	71.4	57.5	34.5		37.4	

Ligumia nasuta

(Table 8)

Ligumia nasuta, while fairly abundant in East Harbor, was very sparse in Fish Hatchery Bay and at Pelee Island. Even though the collections are small they show the same differences as exhibited by the other species studied. Ortmann's selected sample from Lake Erie has an average total length of 82.6 mm. as compared to 77.6 mm. for our East Harbor specimens. He calls attention to the lack of variability in this species and indicates no significant difference in size for the stream and lake forms.

Because of the small number of specimens, very little can be said about the distribution of age classes. The lack of specimens beyond 8 years of age in

TABLE 8
Size and weight averages of each age class for *Ligumia nasuta*.

No. Specimens	Age	Total Length Max.	Total Length Av.	Total Length Min.	Av. Ant. L.	Av. Post. L.	Av. Ht.	Av. Ob.	Weight Max.	Weight Av.	Weight Min.
					East Harbor						
2	1	42	41.0	40	12.5	28.5	18.0	10.0	2	1.5	1
5	3	68	66.0	64	17.0	49.0	27.0	16.8	9	7.5	6
7	4	78	72.1	65	17.7	53.8	29.4	18.8	13	9.9	8
8	5	94	85.4	80	20.5	65.1	34.4	21.5	21	17.3	11
2	6	102	100.5	99	22.5	79.0	38.0	24.5	27	26.0	25
4	7	93	88.3	84	22.0	66.3	37.5	25.2	35	25.3	20
1	8		96.0		26.0	70.0	40.0	26.0		27.5	
Av. of 29 specimens			77.6		19.2	58.4	31.6	20.1		14.8	
					Fish Hatchery Bay						
1	3		54.0		12.0	42.0	22.0	13.0		3.5	
1	6		80.0		20.0	60.0	34.0	23.0		16.2	
1	8		65.0		17.0	48.0	31.0	21.0		14.4	
1	9		78.0		20.0	58.0	37.0	27.0		23.0	
1	14		76.0		22.0	54.0	34.0	25.0		26.2	
Av. of 5 specimens			70.6		18.2	52.4	31.6	21.8		16.6	
					Pelee Island						
1	2		39.0		9.0	30.0	17.0	11.0		2.5	
1	5		60.0		10.0	50.0	24.0	25.0		7.7	
Av. of 2 specimens			49.5		9.5	40.0	20.5	18.0		5.1	

East Harbor may have some interesting significance. This species seems to prefer the quieter waters of lakes.

Ligumia recta
(Table 9)

In contrast to *L. nasuta*, this species was most abundant in the exposed habitat of Pelee Island and least abundant in East Harbor. Due to the relatively small number of specimens and the irregular distribution of age groups, it is not possible to compare the averages for each habitat. A comparison of the six year class shows the average total length and weight for East Harbor to be 10.8% and 32.6%, respectively, greater than those for Fish Hatchery Bay and 29.2% and 54.8%, respectively, greater than those from Pelee Island. Ortmann (1919) considered it inadvisable to designate a stream and lake variety although he describes a difference in size and color. He was unable

TABLE 9
Size and weight averages of each age class for *Ligumia recta*.

No. Specimens	Age	Total Length Max.	Total Length Av.	Total Length Min.	Av. Ant. L.	Av. Post. L.	Av. Ht.	Av. Ob.	Weight Max.	Weight Av.	Weight Min.
					East Harbor						
1	6		121.0		21.0	100.0	51.0	31.0		83.1	
2	7	114	111.0	108	21.5	89.5	46.0	30.5	86	70.7	55
Av. of 3 specimens			114.3		21.3	93.0	47.7	30.7		74.8	

					Fish Hatchery Bay						
1	6		108.0		24.0	84.0	42.0	28.0		56.0	
1	10		112.0		20.0	92.0	46.0	32.0		79.0	
3	11	130	113.3	91	18.0	95.3	45.0	33.0	109	82.3	44
2	12	121	120.0	119	19.5	100.5	46.5	34.5	105	87.5	70
3	13	121	117.0	111	18.3	98.7	48.0	37.7	113	101.0	86
1	15		109.0		18.0	91.0	42.0	29.0		60.5	
Av. of 11 specimens			114.5		19.1	95.5	45.6	33.1		83.7	
					Pelee Island						
1	2		55.0		10.0	45.0	21.0	14.0		7.9	
1	3		61.0		13.0	48.0	23.0	17.0		14.8	
1	4		67.0		14.0	53.0	28.0	29.0		18.4	
4	5	101	91.0	80	18.5	72.5	36.5	25.5	56	40.6	30
4	6	92	85.7	80	17.8	68.0	35.5	25.0	42	87.6	30
3	7	90	85.7	81	16.7	68.3	36.3	25.0	42	36.9	32
1	8		92.0		18.0	73.0	38.0	27.0		44.4	
6	9	98	93.0	84	17.5	75.5	38.5	27.0	59	47.7	29
2	10	95	93.0	91	17.0	76.0	38.5	27.5	64	54.0	44
1	13		105.0		18.0	87.0	46.0	31.0		91.9	
1	14		107.0		22.0	85.0	44.0	33.0		88.0	
Av. of 25 specimens			87.8		17.2	70.5	36.2	25.8		43.4	
					Maumee River						
2	11	137	115.0	93	21.5	93.5	48.5	35.5	145	103.7	63

to distinguish between the young specimens from Pennsylvania streams and Lake Erie. The average total length of Ortmann's selected sample from the upper Ohio drainage is 7 mm. greater than our Fish Hatchery Bay collection. Grier (1920) gives the Lake Erie form the varietal name of *latissima* but fails to show as great differences between the lake and stream form as we found within the lake itself. At any rate, as Ortmann points out, if a variety is to be named it should be the stream form as the type of *Ligumia recta* came from the lake.

Lampsilis siliquoidea

(Table 10)

This species was found to be the most abundant and widely distributed of our collections, although Ortmann regards it as unsuited to strong currents

TABLE 10

Size and weight averages of each age class for *Lampsilis siliquoidea*.

No. Specimens	Age	Total Length Max.	Total Length Av.	Total Length Min.	Av. Ant. L.	Av. Post. L.	Av. Ht.	Av. Ob.	Weight Max.	Weight Av.	Weight Min.
					East Harbor						
2	3	72	64.0	56	18.5	45.5	34.0	26.5	22	17.0	12
8	4	91	80.5	59	31.3	59.2	43.9	31.1	47	33.7	12
19	5	94	84.9	67	21.8	62.9	46.1	34.3	66	42.4	19
51	6	100	85.6	64	22.3	63.2	47.6	35.0	68	46.6	20
27	7	101	90.7	70	23.5	67.0	49.1	36.9	76	51.4	24
12	8	102	91.0	71	22.8	68.2	49.5	37.0	79	53.9	29
7	9	101	97.3	93	24.1	73.1	53.0	40.1	76	68.9	59
3	10	93	85.3	80	22.3	63.0	47.7	38.2	63	50.9	39
2	11	103	102.5	102	22.5	80.0	55.5	41.0	89	78.9	61
Av. of 131 specimens			87.3		22.5	64.7	47.8	35.5		48.1	

Fish Hatchery Bay											
10	3	73	55.9	48	14.1	41.5	30.5	23.0	26	18.7	10
15	4	70	57.9	43	15.0	42.8	33.1	25.0	27	21.8	9
9	5	78	61.4	48	15.0	46.2	34.7	26.2	39	23.7	10
12	6	86	69.9	54	16.9	53.0	38.8	29.1	50	29.1	12
13	7	82	67.5	58	17.2	50.1	37.7	29.7	42	27.9	15
8	8	84	70.1	53	16.7	54.6	38.8	31.9	58	35.1	22
4	9	91	80.8	64	18.3	62.5	44.0	33.3	58	40.1	20
2	10	88	83.0	78	19.0	64.0	43.0	35.0	66	54.0	42
4	11	86	74.5	61	16.0	58.5	41.3	34.2	48	41.6	28
4	12	86	76.8	62	14.2	62.5	39.7	33.0	43	32.5	22
2	13	91	90.5	90	19.0	71.5	47.0	37.0	70	58.8	48
1	15	90	90.0	90	17.0	73.0	47.0	37.0	54	54.0	54
Av. of 84 specimens			66.9		16.1	50.9	37.0	28.7		29.2	
Pelee Island											
1	1		20.0		6.0	14.0	12.0	7.0		0.5	
4	2	49	40.3	33	11.3	29.0	21.7	16.0	12	6.3	3
4	3	50	47.3	45	12.7	34.5	28.3	21.0	16	12.4	10
12	4	67	57.3	53	14.6	42.7	33.7	25.4	25	21.5	13
15	5	67	58.7	45	14.8	43.7	35.0	28.4	35	26.3	15
11	6	73	61.1	55	14.6	46.5	36.0	28.4	37	27.7	21
6	7	77	65.5	56	15.0	50.5	37.3	31.5	40	34.8	21
6	8	72	65.3	59	16.8	48.5	38.2	32.3	51	39.4	31
1	9		68.0		18.0	50.0	40.0	34.0		42.0	
2	10	73	72.0	71	15.5	56.5	44.0	38.0	56	56.0	56
Av. of 62 specimens			58.2		14.5	43.6	34.2	27.2		26.3	

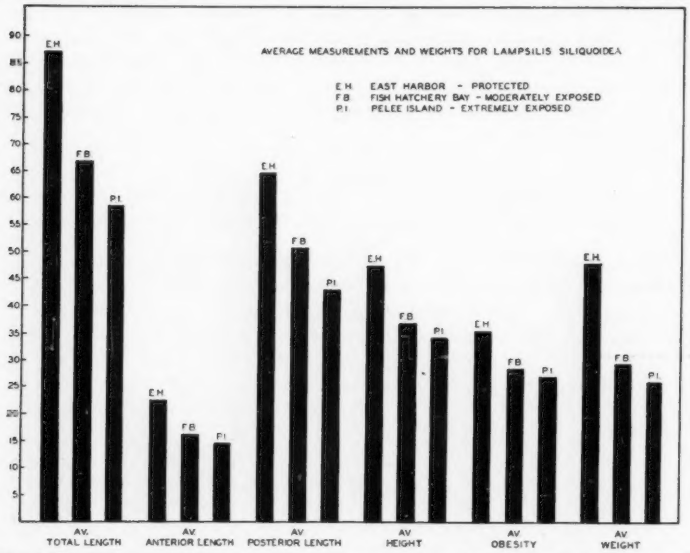

AVERAGE MEASUREMENTS AND WEIGHTS FOR LAMPSILIS SILIQUOIDEA
E.H. EAST HARBOR - PROTECTED
F.B. FISH HATCHERY BAY - MODERATELY EXPOSED
P.I. PELEE ISLAND - EXTREMELY EXPOSED
AV. TOTAL LENGTH
AV. ANTERIOR LENGTH
AV. POSTERIOR LENGTH
AV. HEIGHT
AV. OBESITY
AV. WEIGHT

Fig. 3. Comparison of the average measurements and weights for *Lampsilis siliquoidea.*

and rough bottoms. His selected stream sample has an average total length of 104.7 mm. as compared to 87.3 mm. for our specimens from East Harbor. His Lake Erie specimens had an average length of 68.8 mm., which is very near our average for Fish Hatchery Bay. It is doubtful whether these differences have significance taxonomically, since the variation within Lake Erie itself is greater than the difference between the lake and stream forms.

As in all other species presented there is a more or less consistent variation between specimens of the same species from the three habitats. The largest specimens in all measurements and weights were from East Harbor, the intermediate ones from Fish Hatchery Bay and the smallest from Pelee Island. All of these data for *Lampsilis siliquoidea* are shown graphically in Fig. 3. The growth rate curves based upon the total length averages of each age group, as well as the weights for each age, are shown in Fig. 4. This bears out a previous statement that in most instances there are greater differences between East Harbor and Fish Hatchery Bay specimens than between those of the latter and Pelee Island. Although the abundance of age groups is not

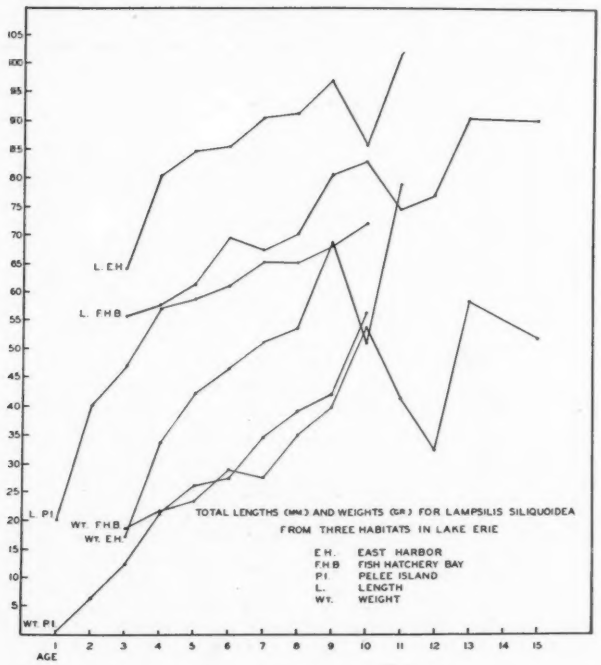


Fig. 4. Showing total lengths and weights for the age classes of *Lampsilis siliquoidea.*

entirely uniform, the differences do not alter the picture a great deal. The 5-8 year classes were most abundant in East Harbor, the 3-7 year groups in Fish Hatchery Bay and the 4-6 year groups in the Pelee Island habitat. The five and six year age classes were abundant in all three habitats. The few irregularities exhibited by older age classes may be due to the small number of specimens or to errors involved in determining their ages.

TABLE 11

Size and weight averages of each age class for *Lampsilis ventricosa*.

No. Specimens	Age	Total Length Max.	Total Length Av.	Total Length Min.	Av. Ant. L.	Av. Post. L.	Av. Ht.	Av. Ob.	Weight Max.	Weight Av.	Weight Min.
					East Harbor						
1	3		70.0		23.0	47.0	50.0	36.0		29.3	
1	5		69.0		19.0	50.0	45.0	35.0		23.8	
2	6	93	86.0	79	26.5	59.5	58.5	44.0	67	54.5	42
2	7	95	94.5	94	29.0	65.5	61.5	44.5	84	76.5	69
1	8		100.0		30.0	70.0	64.0	48.0		88.4	
1	9		107.0		30.0	77.0	71.0	52.0		125.2	
Av. of 8 specimens			88.4		26.6	61.7	58.8	43.3		66.1	
					Fish Hatchery Bay						
1	2		55.0		20.0	35.0	38.0	26.0		9.0	
2	3	64	61.5	59	19.0	42.5	39.0	29.5	18	16.0	14
1	7		85.0		25.0	60.0	56.0	37.0		49.7	
1	8		82.0		26.0	56.0	54.0	40.0		44.2	
1	10		87.0		27.0	60.0	61.0	48.0		79.3	
2	11	99	97.0	95	25.5	71.5	57.0	45.5	100	86.0	72
2	12	91	84.5	78	20.0	64.5	52.0	42.0	87	78.0	69
4	13	99	94.5	92	24.3	70.2	59.0	45.3	100	83.8	71
1	18		96.0		27.0	69.0	59.0	48.0		109.5	
Av. of 15 specimens			84.6		23.4	61.2	53.3	40.9		65.8	
					Pelee Island						
2	1	46	38.0	30	11.0	27.0	26.0	20.0	9	5.0	2
5	2	65	52.4	44	16.6	35.8	35.4	27.0	22	11.7	5
7	3	69	60.7	54	19.3	41.4	40.7	28.7	25	17.8	12
10	4	73	64.9	55	20.0	45.1	42.7	31.7	32	22.0	12
10	5	77	67.7	58	18.9	48.1	44.8	33.6	43	32.2	18
10	6	82	72.1	62	19.5	51.6	48.3	35.5	37	34.2	26
14	7	90	73.4	63	20.6	52.7	48.4	36.9	61	38.9	25
17	8	88	75.6	65	19.5	56.1	49.4	38.0	70	46.8	25
17	9	91	77.7	60	21.3	56.4	51.5	40.0	78	53.5	31
14	10	97	81.6	75	21.6	60.0	52.1	40.9	86	57.7	40
8	11	99	85.0	79	22.3	62.7	53.8	40.8	90	65.6	50
1	12		76.0		20.0	56.0	46.0	39.0		44.4	
3	13	91	82.0	67	18.3	63.7	49.3	41.0	75	58.6	32
2	14	82	81.5	81	21.0	60.5	51.0	41.0	62	60.5	59
3	15	100	88.0	79	24.3	63.6	54.6	43.0	114	83.3	52
Av. of 123 specimens			73.2		20.1	53.0	47.8	36.6		42.7	

Lampsilis ventricosa
(Table 11)

Lampsilis ventricosa was most abundant in the exposed habitat of Pelee Island. Our Fish Hatchery Bay specimens correspond very closely to Ortmann's selected sample from Lake Erie which he has designated as *L. ovata canadensis*. The average of his stream sample is considerably larger than our largest average from East Harbor. Although our samples are small from the two more protected habitats, the averages show the same differences as found in the other species studied. The East Harbor specimens have an average total length and weight of 4.3% and 0.5%, respectively, greater than those from Fish Hatchery Bay; 17.2% and 35.4%, respectively, greater than those from Pelee Island. Our specimens are very similar to those of Grier (1920) when the characters of height and obesity are considered. We did find many typical *ovata* type individuals in the lot, however, and also many which were intermediate between this and the *ventricosa* description.

The most abundant age groups from Pelee Island were between 4 and 10 years. The rather insignificant difference between the specimens from East Harbor and Fish Hatchery Bay may be explained by the uneven distribution of age classes.

Conclusions

The differences found between individuals of the same species from streams and lakes does not seem so singular when series from a large number of habitats within lakes and streams are compared. Such a series certainly shows complete intergradation for the shell characters of size and shape. A suitable stream habitat favors the larger sizes and the exposed large lake habitat, the extreme cases of stunting. The writers are somewhat in agreement with Allen (1922) concerning the comparative favorableness of stream and lake environments. The arguments used by certain workers that streams are characterized by more favorable conditions with regard to current, temperature and food certainly cannot be supported with limnological facts. We disagree with the last named author, however, regarding the importance of wave action on the size and distribution of clams, if he meant to apply his statement to all lakes. The complete lack of mussels on certain wind swept shoals with suitable bottom in Lake Erie is a common feature. The effects of inbreeding expressed by Evermann and Clark (1918) certainly cannot explain the differences within a ten mile radius in one lake whose fauna is practically continuous. Whatever the determining factor or factors may be they certainly are associated with the degree of wave action in Lake Erie. We are not prepared to say whether wave action alone has such a stunting effect resulting from continuous effort on the part of the mussel to stay in place or whether it is associated with some other factor such as food supply or availability. In all probability the differences we observed are due to a series of related factors associated with the degree of wave action or exposure.

Summary

1. Three habitats were selected on a basis of exposure: East Harbor, protected; Fish Hatchery Bay, moderately exposed; Pelee Island, extremely exposed.

2. Over 1000 specimens were collected: the measurements of 8 species are presented.

3. Besides the individual variation found for each species and age group in each habitat, there is a consistent difference in the average size and weight of age classes between the three habitats.

4. A comparison of our measurements with those of other workers shows an almost complete intergradation within the lake and also between the so-called stream and lake forms.

5. Age classes are not uniformly distributed in individual habitats. The intermediate age groups were usually most abundant.

6. The degree of stunting in Lake Erie for all species studied is definitely correlated with the degree of exposure found in the habitats. The more stunted individuals were found in the more exposed lake habitats.

REFERENCES

ALLEN, W. R. 1922—Studies of the Biology of Freshwater Mussels. III. Distribution and movement of Winona Lake Mussels. Proc. Indiana Acad. Sci. 1921: 227-238.

ALTNÖDER, K. 1926—Beobachtungen über die Biologie von *Margaritana margaritifera* und über die Ökologie ihres Wohnorts. Arch. f. Hydrobiol. **17**:423-491.

BAKER, F. C. 1916—The Relation of Mollusks to Fish in Oneida Lake. N. Y. State Coll. For., Tech. Pub. **4**:366 pp.

———1927—The Naiad Fauna of the Rock River System: A Study of the Law of Stream Distribution. Ill. State Acad. of Sci. **19**:103-112.

———1928—The Mollusca of Chautauqua Lake, New York, with Descriptions of a New Variety of *Ptychobranchus* and *Helisoma*. Nautilus **42**:48-60.

BALL, G. H. 1922—Variation in Fresh-Water Mussels. Ecology **3**:93-121.

CHAMBERLAIN, T. K. 1931—Annual Growth of Fresh-Water Mussels. Bur. of Fish. Document **1103**:713-739.

COLTON, H. S. 1922—Variation in the Dog Whelk, *Thais* (*Purpura* Auct.) *lapillis*. Ecology **3**:146-157.

EVERMANN, B. W. AND H. W. CLARK. 1918—The Unionidae of Lake Maxinkuckee. Proc. Indiana Acad. Sci. **1917**:251-285.

GRIER, N. M. 1918—New Varieties of Naiades from Lake Erie. Nautilus **32**:9-12.

———1920—IV. Morphological Features of Certain Mussel-Shells found in Lake Erie, Compared with those of the Corresponding species found in the Drainage of the Upper Ohio. Ann. Carnegie Mus. **13**:145-182.

GRIER, N. M. AND J. F. MUELLER. 1926—Further studies in Correlation of Shape and Station in Fresh-Water Mussels. Bull. Wagner Free Inst. Sci. Phila. **1**:11-28.

HEADLEE, T. J. AND J. SIMONTON. 1904—Ecological Notes on the Mussels of Winona Lake. Proc. Ind. Acad. Sci. **1903**:173-179.

HEADLEE, T. J. 1906—Ecological Notes on the Mussels of Winona, Pike and Center Lakes of Kosciusko Co.. Ind. Biol. Bull. **11**:305-316.

ISELY, F. B. 1914—Experimental Study of the Growth and Migration of Fresh Water Mussels. Bur. Fish. Doc. **792**: 23 pp.

KRECKER, F. H. 1924—Conditions under which *Goniobasis livescens* occurs in the Island Region of Lake Erie. Ohio Jour. Sci. **24**:299-310.

———1931—Vertical Oscillations or Seiches in Lakes as a Factor in the Aquatic Environment. Ecology **12**:156-163.

ORTMANN, A. E. 1919—A Monograph of the Naiades of Pennsylvania. Part III. Systematic account of Genera and Species. Memoirs Carnegie Mus. **8**:1-343.

———1920—Correlation of Shape and Station in Fresh-Water Mussels (Naiades). Trans. Amer. Phil. Soc. **19**:269-312.

VAN DER SCHALIE, H. 1938—The Naiad Fauna of the Huron River, in Southeastern Michigan. Univ. Mich. Mus. Zool. Misc. Pub. **40**. In press.

WALKER, B. 1913—The Unione Fauna of the Great Lakes. Nautilus **27**:1-20.

WIEBE, A. H. 1926—Variations in the Freshwater Snail *Goniobasis livescens*. Ohio Jour. Sci. **26**:49-68.

INSTITUTE FOR FISHERIES RESEARCH,
UNIVERSITY MUSEUMS,
ANN ARBOR, MICH.

Observations on the Natural History of Pomatiopsis lapidaria Say*

Donald J. Ameel

The successful pursuit of the life cycles of helminths usually is dependent upon a knowledge of the ecological relationships of the various intermediate and final hosts. These are often maintained in the laboratory for experimental purposes, and for their well-being it is essential to provide conditions closely resembling those in which they were found in nature. Frequently, an investigator is confronted by the lack of detailed information on the natural history of invertebrate and vertebrate hosts and, therefore, valuable observations of an ecological nature often of necessity accompany the solution of a parasitological problem.

The snail, *Pomatiopsis lapidaria,* came to my attention when I discovered it to be the first intermediate host of *Paragonimus kellicotti,* the North American lung fluke of mammals (Ameel, 1932). Development of cercariae, the aquatic phase of the large group of digenetic trematodes always takes place in some molluscan host, usually of aquatic or amphibious habits. After finding the snail, an attempt was made to learn something of its habits by consulting the conchological literature. However, nothing could be found on its life history and definite information was lacking on its habits, since investigators were not in agreement. Certain workers claim that *P. lapidaria* is terrestrial while others present evidence of its amphibious character. Hence a need for independent observation was evident since the snail would necessarily play an important part in the investigation of *P. kellicotti.* Furthermore, the completion of the life-history studies necessitated keeping the snails in the laboratory for considerable periods of time. The purpose of this paper is to present data on observations made as a corollary of the trematode investigation. Brief reference is made to controversial points in the literature.

Walker (1918) said, "The species of this group are terrestrial or rather semiamphibious in habit, being always found near but not in the water." Baker (1930) contended that the snails should be considered as amphibious rather than terrestrial for, though at most times of the year they occupy damp habitats, they remain immersed in the same situation when the streams overflow. He also reported finding them in a stream of normal depth and in a later paper (Baker 1931) cited four instances where *P. lapidaria* was collected from the bottoms of streams in the summer long after the water had subsided to its normal level. Stimson (1865), Pilsbry (1896) and Shimek (1930a) have considered *P. lapidaria* to be essentially a land snail. Shimek

* Contribution of the Department of Zoology, University of Michigan.

was quite emphatic in his contentions which were based on a study of land snails including observations on the fauna of loess deposits. In a later paper Shimek (1930b) presented several excerpts from Stimson's work in support of his argument. Two of these excerpts with an additional sentence are also quoted here. Stimpson (1865) stated: "That the *Pomatiopsis* is truly terrestrial in its habits, notwithstanding its preference to the vicinity of water, I can have no doubt. Its peculiar mode of progression is, indeed, adapted for land travel only.—The animal may be said to be amphibious, but only in the sense that *Succinea* and some other terrestrial Mollusca are so; that is, like them it is capable of living for a long time under water."

Considerable opportunity was afforded to observe the habits of this snail for they were collected over a period of several years. Though the snails were very abundant in three localities where collections were made, at no time were any observed on the bottom of the adjacent streams. In a marsh bordering a small mill pond on Fleming Creek near Ann Arbor, Michigan, numerous snails were present along a border that often extended about ten feet or more from the water's edge. Because of the dam, the water usually did not overflow much of the area occupied by the snails. However, heavy rains often temporarily immersed those snails occupying the numerous depressions. A heavy rain in the spring of 1933 caused the stream to overflow covering the habitat of the snails to a depth of two and one-half to three feet. The water gradually receded over a period of a week during which time the snails remained submerged and made no effort to leave the water.

P. lapidaria is more or less nocturnal. On bright days, the snails remain hidden under the leaves and other cover but expose themselves on dull days or in well shaded situations provided their cover is well saturated with moisture. Several visits were made to the habitat under discussion on warm humid evenings and on each occasion numerous snails were found in exposed situations. Many were upon the ground, some were partially or completely submerged in small pools of water and others had climbed up the standing vegetation to a height of 8 inches or more. On the days following these observations, the snails had taken to cover.

The snails were under continuous observation from July 1931 until the middle of October 1932, including the mild winter of 1931-1932. During that time, the snails appeared to remain constant in number over the whole extent of their habitat. Apparently there is no seasonal movement to the open water of the stream.

Associates in the above habitat are: *Succinea avara* Say, *S. retusa* Lea, *Carychium exiguum* (Say), *Gastrocopta armifera* (Say), *Polygyra multilineata* (Say), *Polygyra* sp., *Zonitoides arborea* (Say), *Cochlicopa lubrica* (Müller) and *Agriolimax campestris* (Say). These were identified by Mr. Calvin Goodrich of the Museum of Zoology, University of Michigan.

P. lapidaria was also found in large numbers along a small stream on the outskirts of Ann Arbor. Here, too, the land was low and marshy but rarely

subject to overflow. Snails were collected as far as 15 to 20 feet from the stream wherever the soil remained fairly moist and there was sufficient cover. A fire which destroyed all standing vegetation occurred in 1932 but the snails seemed to be as abundant as ever the following year.

This species was collected along Swan Creek at Newport, Michigan, where they occurred in extraordinary abundance in a limited area occupied by a growth of poison ivy and small maples. The snails extended in practically undiminished numbers to the top of the bank which was at least 15 feet from the water's edge and about 10 feet above the level of the water. The soil was damp but there was no unusual amount of seepage. Indications were that only an exceptional flood would ever cause the water to rise to the top of the bank. By the summer of 1935, several years of drought had so affected this habitat that the snails were reduced to a few scattered individuals at the water's edge.

Apparently, if adult snails are in good condition, they can withstand long periods of desiccation. On several occasions, snails were collected and permitted to remain in open containers in the laboratory for as long as two months. When they were placed in water, most of them became active. Very young snails (about 1 mm. long) can withstand only a few days of desiccation.

In the first attempts to keep *P. lapidaria* alive in the laboratory, they were placed in aquaria containing moist soil covered with decomposing leaves to provide cover and food. This arrangement was not satisfactory, for most of the snails soon died, possibly from too great humidity. Uncovered shallow dishes provided with damp soil and decomposing leaves were then used with satisfactory results.

Snails to be examined for cercariae were placed in small wide-mouth bottles containing a little water and these were examined daily over a 3 to 4 day period under a low binocular microscope. These repeated observations were required because most of the snails, after a short period of submersion crawled out of the water. A few remained immersed for extended periods and some lingered partially immersed at the water's edge. Since the water was changed daily and the snails thrust back into it, infected individuals could usually be detected during this brief examination period. If the sojourn in the bottles is extended beyond three days, the snails begin to die. On one occasion, the majority of a collection of small snails placed in watch glasses stacked one upon another remained in the water continuously for several days.

Four species of tailed cercariae in addition to *Paragonimus* have been recovered from *P. lapidaria*. One of these, an eyed form, was discussed by Stimpson (1865) who found it frequently when he made a study of the anatomy of the snail. The fact that this snail is the intermediate host for that many species of trematodes is striking evidence that it possesses greater amphibious tendencies than are generally credited to it, for no essentially terrestrial snail would be utilized in the life histories of these trematodes for which

a definite aquatic phase is required. It is necessary for the survival of these species to parasitize a more or less aquatic snail. This last observation is irrefutable. These cercariae have been the object of further research the results of which will be published in the near future.

It is obvious that the weight of evidence presented in this paper strongly supports the statements of Baker as to the amphibious character of *P. lapidaria*.

REFERENCES

AMEEL, D. J. 1932—Life history of the North American lung fluke of mammals. Jour. Parasitol. **18**:264-268.

BAKER, F. C. 1930—Notes on Professor Shimek's paper as indicators of ecological conditions. Ecology **11**:788-789.

———1931—Ecological relationship of the genus *Pomatiopsis* with special reference to *Pomatiopsis lapidaria*. Ecology **12**:489-496.

PILSBRY, H. A. 1896—A new species of *Pomatiopsis*. Nautilus **10**:37-38.

SHIMEK, B. 1930a—Land snails as indicators of ecological conditions. Ecology **11**:673-686.

———1930b—Comments on Mr. Baker's "Notes." Ecology. **11**:789-791.

STIMPSON, W. 1865—Researches upon the *Hydrobiinae* and allied forms. Smith. Miscel. Coll., **7**(201):1-59.

WALKER, B. 1918—Ward & Whipple: Fresh Water Biology. John Wiley & Sons, Inc., New York. 1111 pp.

DEPT. OF ZOOLOGY,
KANSAS STATE COLLEGE,
MANHATTAN, KANSAS.

On Some Cenozoic Brachiopoda from the North American Region

Kotora M. Hatai

The Recent and Tertiary Brachiopoda of North America and the West Indies comprise a very interesting group from the viewpoint of both geographical distribution as recent and as fossil on the one hand, and localization of fauna on the other. However, it is very unfortunate, that since the appearance of the works of C. Schuchert in 1897 and that by W. H. Dall in 1920, we have no comprehensive literature by which we may know the fossil Tertiary and Recent brachiopod-fauna of the North American and West Indian region, according to present usage of the different genera.

S.Nomura and K.Hatai in 1937 and K.Hatai in 1936 both published accounts of the brachiopods of North America and the latter author of the West Indian fauna as well. However, since the works by S.Nomura and K.Hatai are confined to only a few species of the West coast Neogene and of some recent forms from the eastern Pacific, the present article is hoped to be of some aid in getting a general idea of our present knowledge concerning the fauna of the stated region. This article is preliminary to one which will appear with the accumulation of further material. The material now at hand came from Neogene deposits of the western (Pacific) coast of North America on the one hand and from the recent seas in the region extending from British Columbia at the north to Lower California at the south, a very small area.

Genus *Glottidia* Dall, 1870

Glottidia is a genus founded by Dall upon *Lingula albida* Hinds, a recent species from Lower California. In regard to the distinction of *Glottidia* from *Lingula*, Morse remarks:

> Aside from the internal structure of the dorsal and ventral shell, the form of the protegulum, the presence of gill ampullae, the arrangement of the oblique muscles, and the more anterior position of the coelomic cavity, I found that in Glottidia the setal tubes were not formed, though the lateral setae assume a vertical position in the sand, as in *L. lepidula;* the sand tube is much more complete and symmetrical, and in alcohol is retained on the peduncle, while in *L. lepidula* the sand tube becomes detached. . . . . Charles Schuchert ('97), in considering the enormous period in geological history occupied by the *Lingulidae*, says that the only change observable is that in the ancient forms the viscera occupy a little more and the brachia a somewhat less space than in the later forms. Glottidia by these characters is a more ancient type.

Even though *Lingula* and *Glottidia* are very similar to each other, it is interesting to notice that *Glottidia* has not been recorded as fossil, while *Lingula* has been recorded from ages as early as the Paleozoic. Probably many of the species named as *Lingula* may belong to *Glottidia*. In the recent seas, *Glottidia* is confined in distribution to the two sides of America, while *Lingula* is restricted to the Central and Western Pacific and Indian Oceans.

The known species of the genus *Glottidia* and their respective distributions are given in the following:

Glottidia albida (Hinds)
Type locality: — Magdalena Bay, Lower California, 7 fathoms.
Distribution: — Lower California.

Glottidia palmeri Dall
Type locality: — Head of the Gulf of California.
Distribution: — Lower California.

Glottidia audebarti (Broderip)
Type locality: — Isle of Punam, Bay of Guayquil, 7 inches.
Distribution: — Guayquil and Mexico.

Glottidia pyramidata (Stimpson)
Type locality: — Beaufort, North Carolina.
Distribution: — North Carolina and Florida.

Genus *Pegalodiscus* Dall, 1908

The species belonging to this genus have small shells, unequal valves, and the dorsal valve is conical with the apex slightly posterior to the center. The ventral valve is smaller than the dorsal and nearly circular in outline. The shell is very thin, semi-transparent and sculptured by numerous close-set concentric growth lines.

There are known only two fossil species, namely, (?) *Discina suessi* Bosquet from the Lower Miocene of Belgium, and *Discina fallens* S.Wood from the Crag of England. The only known living species is: *Pegalodiscus atlantica* (King).

Type locality: — North Atlantic Ocean, 1,366 fathoms.
Distribution: — Cosmopolitan, generally abyssal, up to 2,737 fathoms, but in 200 fathoms in the Celebes.

Genus *Discinisca* Dall, 1871

This genus includes species dating back to the Cretaceous of Canada and North America, in the Tertiary of the United States of America, the Oligocene of Holland, Miocene of the Vienna Basin and Poland, while the recent species of the North American region are listed below.

Discinisca laevis (Sowerby)
Type locality: — Concepcion, Chile, 6 fathoms.
Distribution: — Lower California, Chile and Peru.

Discinisca strigata (Broderip)
Type locality: — Cana Island, Guatemala, 18 fathoms.
Distribution: — California, Panama and Mexico.

Discinisca cumingii (Broderip)
Type locality: — Payta, Peru, 6 fathoms.
Distribution: — Peru, Panama and Mexico.

Discinisca antillarum (d'Orbigny)
Type locality: — Cuba, on coral.
Distribution: — Cuba, Jamaica, Nicaragua, and Brazil.

Discinisca lugubris (Conrad)
Tye locality: — Unknown to writer.
Distribution: — Older Miocene of Shiloh, Cumberland County, New Jersey; Miocene of Atlantic City, New Jersey; Miocene of Maryland; Miocene of Virginia and North Carolina; Pliocene of the Caloosahatchies Marls in South Florida (after Dall). Ranging from the Eocene, Miocene to the Pliocene (according to Thomson).

Discinisca oregonensis (Dall)
Type locality: — Miocene shale of Coos Bay, Oregon.
Distribution: — Miocene of Oregon, Northwest America.

Genus *Crania* Retzius, 1781

The generic characters of this genus, according to Thomson, are:

Shell inequivalve, ventral valve cemented to its support by almost its whole surface, dorsal valve more or less conical, apex subcentral, directed posteriorly, outline subcircular to subrectangular, posterior margin straight or slightly indented; test smooth or with radiating striae, ribs, or spinules, calcareous, penetrated by vertical canals which repeatedly branch towards the outer surface. Interior with muscular impressions generally strongly marked, especially the posterior adductors, which lie near the posterior margin some distance apart, and the anterior adductors, which are only a little behind the centre of the valves and are close together. In front of the muscular impressions the interiors of the valves show 4-7 grooves on each side, being the impressions of the pallial sinuses. Mantle without marginal setae, brachia spirolophus with the apices of the spires directed dorsally, five to eight coils.

The geological range of the genus, according to Hall and Clarke is from the Lower Silurian to the recent. The Tertiary species of this genus occur in the Eocene of Belgium and Italy, the Miocene of France and Italy, and in the Pliocene of Sicily and Calabria as well as in Italy. None are known at present from the Tertiary deposits of North America.

Crania pourtalesii Dall
Type locality: — Off Samboes reef, Florida Keys, 116 fathoms.
Distribution: — Florida and Cuba.

Crania californica Berry
Type locality: — Off California, 100 fathoms.
Distribution: — California.

Genus *Thecidellina* Thomson, 1915

The species belonging to this genus are very interesting in their peculiar shape of shell, and the generic diagnosis as given by Thomson, is as follows:

Shell small, rostrate, subtrigonal with a straight hinge-line, biconvex, dorsal valve nearly flat, attached by the ventral surface of the beak, test smooth or with rude concentric sculpture, punctate. Beak apicate, without foramen, area flat, without deltidium. Ventral valve finely granulose, internally; hinge-teeth not strong, projecting forward from the cardinal margin; interior of the beak hollow, with a small median septum from which two prongs project a little beyond the hinge-line. Dorsal valve with socket-ridges projecting squarely posteriorly and uniting medianly with one another to form a

rectangular "cordinal process," or "hinge-plate," hollowed dorsally in the middle. The broad granulated margin of the valve is produced posteriorly into a bridge in front of the cardinal process over the visceral cavity, and anteriorly into a long posteriorly pointed median septum, reaching back nearly to the latitude of the bridge. The deep cavities on each side between the septum and the margin are partly occupied by brachial lamellae which run outwards and forward from the end of the septum in a curve conforming nearly to that of the bridge and margin, and anteriorly are reflected inwards and backwards along the side of the septum. The muscles and lophophore have not been described, but the former are doubtless similar to those of *Lacazella*, while the latter is undoubtedly schizolophus. Presumably also the mantles, as in *Lacazella*, are highly spiculated.

The fossil species of the genus occur in the Ototaran (Miocene) of New Zealand, the Miocene of Italy, and the Upper Pliocene of the West Indies. The American species is only one.

Thecidellina barretti (Davidson)

Type locality: — Jamaica, West Indies.

Distribution: — West Indies.

Genus *Cryptopora* Jeffreys, 1869

Shell small, triangularly oval, biconvex to sulcate, test smooth, thin and transparent, impunctate, fibrous with rather large fibres. Beak short, not incurved, foramen hypothyrid, incomplete, deltidial plates rudimentary. Hinge-teeth very small, supported by short, divergent, dental plates. In the dorsal valve there is a small cardinal process over the umbo, from the base of which a mesial septum, low posteriorly, high and overhanging anteriorly, extends to about half the length of the valve. The crura spring from the inner sides of two feeble socket-ridges, and are short, slender, curved outwardly and ventrally, and are denticulate at their extremities. The animal has not been described (Thompson, 1927).

The fossil species of this genus are mostly questionable forms, and as known at present we have one in the Miocene of Vienna, one in the Miocene of Sardinia, one in the Miocene of Italy, and one in the Miocene of Victoria. There are only two recent species, both of which are remote in the area of distribution. One occurs in the east Australian region in 17-100 fathoms, and the other is:

Cryptopora gnomon Jeffreys

Type locality: — North Atlantic, northwest of Ireland.

Distribution: — North Atlantic Ocean, Florida and Cuba.

Genus *Neorhynchia* Thomson, 1915

This genus contains but a single species whose genotype has not been figured, but the cardinalia is probably similar to that of *Hemithyris*, with no internal hinge-plates.

According to Thomson,

Neorhynchia agrees with the Triassic *Norella* Bittner in the dorsal sulcation and smooth test, but lacks the umbonal callosities which Buckman considers an important character of the latter. It possibly represents the norelliform stock from which the rhynchonelliform Recent genera such as *Hemithyris* or *Tegulorhynchia* have been derived, but a fuller knowledge of the cardinalia is necessary for a discussion of these points. Its abyssal bathymetric range suggest considerable antiquity for the genus.

The generic description of the single species was given by Thompson in the following way:

Shell transverse, sulcate; test extremely thin, impunctate, rather coarsely fibrous, smooth and polished. Beak short; foramen hypothyrid, incomplete. Hinge-teeth supported by dental plates. Dorsal valve with a thin thread-like mesial septum. Socket-ridges small, short, close; crura short, blade-like, recurved. Muscular impression obscure. Animal unknown.

Type locality: — Mid-Pacific, 2,084 fathoms.
Distribution: — Mid-Pacific, off Galapagos Island.

Genus *Hemithyris* d'Orbigny, 1847

Hitherto many different kinds of species have been placed in the genus *Hemithyris,* mainly upon the reason that the characters of the beak, shape and folding of the shell closely similate the genotype, *psittacea.* However, from the studies of Chapman and Crespin, we are now well informed that generic separation exists in the many species hitherto referred to this genus. *Tegulorhynchia,* a genus founded by Chapman and Crespin includes species originally placed in *Hemithyris;* its separation from *Hemithyris* is based on the following characters.

In regard to the ornament, *Hemithyris* is typically smooth, or striate, never distinctly costate, so far as we have seen from the specimens in the National Museum collection, which were dredged from the North Sea. In these examples, also, the growth-lines are purely concentric and never tend to become strongly undulose or overlapping to the extent of even a form like the living *nigricans.* In *Hemithyris* the septum is rudimentary, low, and barely extending half-way across the shell. In *Tegulorhynchia* the septum is more strongly developed, and extends into the anterior half of the shell. The deltidial plates in a typical *Hemithyris psittacea* are elongated in the form of a scalene triangle, whereas in *Tegulorhychia* they are almost, to quite, equilateral. These plates are strongly discrete in *H. psittacea,* whereas in *Tegulorhynchia* they may be only so *(T. coelata),* or conjunct *(T. squamosa).*

Considerable difference is found between the genotypes of *Tegulorhynchia* and *Hemithyris;* in the former the beak is erect and more often quite blunt while in the latter it is sharply pointed and incurved; also the dental plates in the latter are said to be weaker and less stout compared to those of the former; another important distinction lies in the shell sculpture, as mentioned above.

Formerly the genus *Rhynchonella* was given a long geological range in time, but as now employed, according to Grabau and Schuchert, it ranges from the Jurassic to the Cretaceous. *Hemithyris* dates back to the Tertiary according to Grabau, Schuchert and Thomson, although Oldroyd states that it goes back to the Silurian. *Acanthothyris* is a Jurassic genus stated to include the Japanese *Rhynchonella döderleini* Davidson, a species now clearly known to belong to the genus *Tegulorhynchia* as established by Chapman and Crespin.

The genotype has been described by Thomson, in the following manner:

Shell ovately triangular, uniplicate, rather globose; test impunctate, smooth to radially striate (? capillate). Beak prominent, erect, produced dorsally of the area, apicate; foramen hypothyrid, incomplete, deltidial plates acutely trigonal, produced ventrally to form a short, anteriorly excavate pedicle-collar, supported anteriorly by a minute septal ridge. Hinge-teeth prominent, supported by high, long,vertical dental plates, tending to become obsolete in gerontic individuals. In the dorsal valve a small, low, septal ridge separates the muscular impressions but does not unite with the cardinalia. The socket-

ridges rise from the sides of the shell, and overhang inwardly; on their upper inner sides they are united with the rather flattened, divergent, crural bases, which are thus excavate beneath; there are no interior hinge-plates. A small cardinal process or straited muscular area, deeply embayed in front, is present in the umbonal region, resting both on the crural bases and socket-ridges, and forming two minute ears at the sides of the umbo. The crura are short, flattened, and curved ventrally. Muscular impressions not strong; in the ventral valve they reach forward nearly to the middle of the valve; the adductors from a small, narrow, heart-shaped impression, situated mesially and surrounded by the much larger diductor impressions, which have the form of two blunt-toed feet with the soles inclined towards the middle. Behind these are situated the ventral pedicle-muscles. In the dorsal valve the adductor impressions also reach forward nearly to the middle of the valve, the anterior being the larger, and the posterior lying mostly outside the hinder end of the anterior impressions. The mantle is fringed marginally with a few short setae. The brachia are spirolophus, the apices of the spires being directed inwards and dorsally, with 12-13 coils.

This genus does not contain very many species, but in the Tertiary of North America are found several interesting species, as follows:

Hemithyris psittacea (Gmelin)

Type locality: — Mari Groenlandiae.

Distribution: — Seas around Japan, West Atlantic, Maine, East Atlantic, Northumberland, Greenland, Spitzbergen, Franz Josef Land, Norway, Alaska, Canada, and Washington.

Distribution in fossil state: — ?Oligocene, Miocene to Pleistocene and recent in Japan; Pliocene of Belgium and England. Pleistocene clays of the Gulf of St. Lawrence and New England region; bowlder clays of Alaska and Northern Europe.

Hemithyris psittacea alaskana Dall

Type locality: — Older Pliocene, near Nome, Alaska.

Distribution: — Pliocene of Alaska. Not known as living.

Hemithyris astoriana Dall

Type locality: — Miocene of Astoria, Oregon.

Distribution: — Miocene of Oregon. Not known as living.

"Hemithyris" washingtoniana Dickerson

Type locality: — Cowlitz formation in southern Lewis County.

Distribution in fossil state: — southern Lewis County, Washington.

This species was named as new to science, but was neither figured nor described as well as compared with other similar species. Therefore, the characters on which it is based are unknown.

Genus *Frieleia* Dall, 1895

This genus contains but a single species, *F. halli* Dall originally described upon material from Cortex bank, California in 984 fathoms, and now known to be distributed from Northern Japan, Kamchatka to Alaska, on to British Columbia, Washington, Oregon, south to California. The bathymetric range of this genus is from 21 to 1,059 fathoms.

Hemithyris ? sp., described by Tegland from the Upper Oligocene type Blakely of Washington, may be *F. halli*, for the description of her species as:

Shell small, thin, imperforate, trigonal in outline. Dorsal valve with a medial groove which gives a bilobed aspect to the anterior margin.

strongly suggests the genus *Frieleia*, in the bilobed nature of the shell. Dall has already stated that a considerable proportion of the specimens he studied, are more or less distinctly bilobed, a condition which is not accidental, while others which he observed, show hardly such a trace of lobation. Tegland believed her specimen, which is said to be too poorly preserved for an accurate generic determination, to be suggestive of the genus *Aetheia* of Thomson. *Aetheia* is a genus established by Thomson for a species from the Oamaruian (Eocene to Miocene) of New Zealand, and the species now known of the genus are distributed in living state in the Indian Ocean and Australian region, and as fossil in the Tertiary of New Zealand. Therefore, the possibility of her species belonging to *Frieleia* seems to be more probable than its belonging to *Aetheia*. Should it belong to Frieleia it would substantiate Thomson's statement:

The genus may certainly be expected fossil in the Tertiary of Japan and western America, but being a form of apparently great antiquity it is quite likely to have had a wider range geographically in earlier geological periods.

Whatever the species may turn out to be, it is certainly important for further interpretation of the geological history of the genus *Frieleia*, and represents a significant extension of the geographical distribution of *Aetheia*.

Genus *Hispanirhynchia* Thomson, 1927

The two Eocene species of this genus from the Tertiary of Italy are apparently questionable as to generic determination, but the Pliocene species from Italy certainly seems to belong to this genus. The living species are found in the Philippine region (161-298 fathoms), and East Atlantic from the English Channel to the Canary Islands (240-1,102 fathoms), and the only American species is:

Hispanirhynchia craneana (Dall)
Type locality: — Off Cocos Island, Gulf of Panama, 1,175 fathoms.
Distribution: — Gulf of Panama.

Genus *Chlidonophora* Dall, 1903

This genus contains species from the Cretaceous of Europe and North America, Tertiary ones from North America and Italy, and recent species from the North Indian Ocean, and

Chlidonophora incerta (Davidson)
Type locality: — Between Sierra Leoene, Africa and the Islands of Fernando de Noronha, South Atlantic.
Distribution: — Tropical Atlantic, Gulf of Mexico, off Bequia Island, and Havana.

The only known Tertiary species of North America, *Terebratula (Chlidonophora) filosa* Conrad, is said to occur in the Eocene of Alabama, the Cretaceous (rotten limestone) of Alabama at Uniontown, and in the Cretaceous of Texas. A questionable species, (?) *Terebratula guadalupae* Roemer, is stated to occur in the Cretaceous of Texas.

The superficial resemblance of this genus to that of *Terebratulina* is considerable, and for the sake of further references, the generic diagnosis of *Chlidonophora* as given by Thomson is stated below.

Shell small, suborbicular with a broad, straight hinge-line, biconvex rectimarginate to incipiently uniplicate, test capillate, punctation fine. Rostrum apicate, foramen hypothyrid, deltidial plates discrete. Hinge-teeth without dental plates. Cardinalia projecting beyond dorsal umbo; apparently a transverse cardinal process is present, but no hinge-plates. Loop short and simple, consisting of two crura which converge and give off two approximating crural processes, descending branches united to form a semicircle without a definite transverse band; the loop projects obliquely ventrally. Muscular impressions not described. Lophophore probably schizolophus; spicules similar to those of *Terebratulina*. Pedicle of variable length, dividing into a rosette of long filaments. Setae half as long as the shell.

Genus *Terebratulina* d'Orbigny, 1847

This genus is the most prolific in species of all recent and Tertiary genera, but has a few species in the North American Tertiary and recent seas. As known at present, *Terebratulina* has species in the Jurassic of Europe and India, in the Cretaceous of Europe and North America, and is represented in nearly all modern seas. As this is a well known genus probably its generic diagnosis is here unnecessary.

Terebratulina septentrionalis (Couthouy)
Type locality: — North America.
Distribution: — Northwest Atlantic Ocean.

Terebratulina unguicula (Carpenter)
Type locality: — Monterey, California.
Distribution: — Northeast Pacific coast.
Distribution in fossil state: — Lincoln County Miocene.

Terebratulina brundidgensis Aldrich
Tyle locality: — Eocene of Brundidge, Alabama.
Distribution in fossil state: — Alabama.

Terebratulina caelleti Crosse
Type locality: — Guadeloupe Island, West Indies.
Distribution: — West Indies.

Terebratulina kiiensis Dall and Pilsbry
Type locality: — Coast of Kii, Japan.
Distribution: — Kii, Japan to Alaska on to Washington and California.
Distribution in fossil state: — Miocene to Holocene in Japan.

Terebratulina crossei Davidson
Type locality: — Sagami Bay, Japan.
Distribution: — Kii, Japan, north to California.
Distribution in fossil state: — Miocene to Holocene in Japan.

Terebratulina lachryma Morton
Type locality: — Eocene of North Carolina.
Distribution in fossil state: — Eocene limestone of Wilmington, North Carolina; near Charleston and on the Revenel plantation, South

Georgia, at a depth of 230-240 feet, and from the Jacksonian Eocene of Choctow County, Alabama (after Dall).

Terebratulina tejonensis (Stanton)
Type locality: — Crescent formation, Crescent, Washington.
Distribution in fossil state: — Washington.

Terebratulina washingtoniana Weever
Type locality: — Unknown to writer.
Distribution in fossil state: — Cowlitz phase of Washington and Chehalis formation of California.

Genus *Cnismatocentrum* Dall, 1920

Cnismatocentrum sakhalinensis Dall
Type locality: — Southeast coast of Sakhalin Island, 64-100 fathoms.
Distribution: — Kurile Islands, Southeast coast of Sakhalin Island and Alaska.

Genus *Gryphus* Megerle von Mühlfeldt, 1811

Gryphus bartletti Dall
Type locality: — Barbados, 73 fathoms.
Distribution: — West Indies.

Gryphus cubensis (Pourtales)
Type locality: — Off Havana, Cuba, 270 fathoms.
Distribution: — West Indies.

Gryphus moseleyi (Davidson)
Type locality: — West of Kerguelen Island, 210 fathoms.
Distribution: — Off New Jersey, off Martinique, Gulf of Panama.

Gryphus clarkeana (Dall)
Type locality: — Gulf of Panama, 1,175 fathoms.
Distribution: — Gulf of Panama, Southwest of Galapagos Island.

Genus *Liothyrella* Thomson, 1916

Liothyrella uva (Broderip)
Type locality: — Gulf of Tehuantepec, 10-12 fathoms.
Distribution: — Guayquil and Gulf of Panama.

Genus *Dyscolia* Fischer and Oehlert, 1890

Dyscolia wyvillei (Davidson)
Type locality: — Off Culebra Islands, West Indies, 390 fathoms.
Distribution: — West Indies, Eastern Atlantic and Indian Ocean.

Genus *Abyssothyris* Thomson, 1927

Abyssothyris wyvillei (Davidson)
Type locality: — Australia.
Distribution: — Off South Australia and north Queensland, in the northwest Pacific, southwest of the Galapagos Islands, off Valparaiso and the west coast of Patagonia, and near the Falkland Islands.

Genus *Argyrotheca* Dall, 1900

Of this genus, five species occur in the Oligocene of Europe, four in the Miocene of Italy, one in the Miocene of New Zealand, one in the Miocene of the Vienna Basin, two in the Miocene of France, one in the Miocene of Russia and Austria, and two in the Miocene of Poland, one in the Miocene of the West Indies, and one in the Miocene of Florida; one in the Pliocene of England, and one in the Pliocene of Italy. The recent species are rather widely distributed, being known from the Australian region, Mediterranean Sea, West Indies and Floridan seas, and along the east coast of South America, as well as along the west coast of Europe and Africa. The American species are listed below.

Argyrotheca lutea (Dall)

Type locality: — Tortugas, 30-43 fathoms.

Distribution: — Florida, West Indies, and off Rio Janeiro.

Argyrotheca barretiana (Davidson)

Type locality: — Northeast coast of Jamaica, West Indies, 150 fathoms.

Distribution: — Florida, West Indies and off Rio Janeiro.

Argyrotheca schucherti Dall

Type locality: — Miocene of Florida.

Distribution in fossil state: — Miocene marl of Jackson Bluff, Ocklochonne River, Florida (Dall)

Argyrotheca powersi Gardner

Type locality: — Butler Dome, Freestone County, Texas. Eocene.

Distribution: — Texas.

This species was derived from a conglomeratic ferruginous limestone in the Eocene Midway formation.

Genus *Platidia* Costa, 1852

Platidia marylandica Clarke

Type locality: — Eocene of the Aquia horizon, upper Marlboro, Maryland.

Distribution: — Eocene of Maryland.

Platidia anomioides Scacchi and Philippi

Type locality: — Mediterranean (?).

Distribution: — Mediterranean, East Atlantic, Florida, and the West Indies.

Distribution in fossil state: — Miocene of the Vienna basin and Poland, the Pliocene of Italy.

Platidia hornii Gabb

Type locality: — Pleistocene of Santa Barbara, California.

Distribution in fossil state: — Pleistocene of California. Not known as living.

Platidia radiata Dall

Type locality: — California (?).

Distribution: — California and West Indies.

Platidia cretacea Weller occurs in the Cretaceous of New Jersey, and is probably the oldest known valid species of the genus.

Genus *Pantellaria* Dall, 1919

Pantellaria echinata (Fischer and Oehlert)

Type locality: — Off Cape Bajar, West Africa, 640-782 fathoms.

Distribution: — West coast of Africa, Barbados, Sand Key, Florida, Cape of Good Hope, New South Wales (?).

Pantellaria is a genus much resembling *Mühlfeldtia,* and is distinguished only in possessing an amphithyrid instead of a submesothyrid foramen, and in the flattening of the dorsal valve, together with its lack of radial ornament.

Genus *Macandrevia* King, 1859

It is interesting to notice that no fossils of this genus have been recorded from the Tertiary deposits of North America, and that fossil but not living species have been recorded from the region of Japan. The only fossil species of this genus are now known to occur in the Pliocene of Italy and Sicily, and the Quaternary of Norway, Sweden and Italy, while in Japan the ages are Middle Miocene and a formation transitional between the Miocene and Pliocene.

According to Thomson,

> *Macandrevia* is the only genus of the Terebratellidae in which the absorption of the septum which is present in the younger loop stages has resulted in its complete disappearance. This suggests a long geological history after the terebrataliform loop stage has been passed, for which, however, evidence is wanting. The geographical distribution on both sides of the Atlantic and on both sides of the American continents equally suggests a long geological history, extending at least to the Eocene.

The occurrence of the genus *Macandrevia* in the Japanese strata raises problems making complicate the question of migration and geological history of it. Literature shows that its discovery in Japan was not expected, although, as Thomson states, "The southward migration of *Macandrevia* must be assumed to be post-Miocene, since no species of the genus are known from the Oligocene-Miocene of South America, the Antarctic, or New Zealand." Thus, the Japanese occurrence of *Macandrevia,* makes the route of assumed migration difficult, and, if the oldest date were taken to be an aid in locating the origination of the genus, the Japanese Tertiary must be given much more attention by foreign workers, than hitherto.

The species occurring in American waters are listed below.

Macandrevia novangliae Dall

Type locality: — Off Marthas Vineyard, 137 fathoms.

Distribution: — East coast of the United States.

Macandrevia americana Dall

Type locality: — Off the coast of Southern Chile, 122 fathoms.

Distribution: — West coast of America, from Chile to California.

Macandrevia craniella Dall

Type locality: — Off Cocos Island, Gulf of Panama, 1,175 fathoms.

Distribution: — Gulf of Panama.

Macandrevia diamantina Dall

Type locality: — Off Cocos Island, Gulf of Panama, 1,175 fathoms.
Distribution: — Gulf of Panama, off Peru, of Coasts Land, Antarctica.

Genus *Diestothyris* Thomson, 1916

Diestothyris frontalis (Middendorff)
Type locality: — South coast of the Okhotsk Sea.
Distribution: — Kurile Islands, Japan Sea, Aleutian Islands, Alaska and Canada.
Distribution in fossil state: — Pliocene of Japan.

Diestothyris frieli (Davidson)
Type locality: — Off Halifax, 1,340 fathoms.
Distribution: — Halifax and Philippine Islands.

Diestothyris spitzbergensis (Davidson)
Type locality: — Spitzbergen Islands (?).
Distribution: — Arctic, Spitzbergen, Iceland, and North Atlantic coasts from Cape St. Vincent to Gulf of St. Lawrence.
Distribution in fossil state: — Pleistocene of Canada, Sweden, and Norway.

Genus *Terebratalia* Beecher, 1893

The species of this genus are all confined in their fossil distribution to the Tertiary deposits bordering the Pacific Ocean of the Northern Hemisphere, and the living species are also restricted to the same area of distribution; the southern boundary mark probably lies in the region north of the Philippine Islands.

The living and fossil species known from Northwest America, are:

Terebratalia rubescens Dall
Type locality: — San Pedro, California.
Distribution: — California.

Terebratalia caurina (Gould)
Type locality: — Puget Sound, Washington.
Distribution: — Northeast Pacific from Alaska to California.

Terebratalia transversa (Sowerby)
Type locality: Puget Sound, Washington.
Distribution: — Northeast Pacific from Alaska to California.
Distribution in fossil state: — Sooke formation of Washington, and in the Pleistocene of Canada.

Terebratalia hemphilli Dall
Type locality: — Pliocene of the Pacific Coast.
Distribution in fossil state: — Upper and Lower Pico formations of Ventura County, Fernando formation of Bath-House Beach and Arroyo Burro, both in Santa Barbara, California.

Terebratalia kennedyi Dall
Type locality: — Cerros Island, Lower California.
Distribution in fossil state: — Cerros Island, Lower California; southwest of Lompoc, Santa Barbara, California.

Terebratalia whitneyi (Gabb)
Type locality: — Miocene of Napa County, California (?).
Distribution in fossil state: — Miocene of California.
Terebratalia caurina is said to occur in the Pleistocene of British Columbia, and Pliocene of California.

Terebratalia transversa (Sowerby) n. subsp. Clark and Arnold
Type locality: — Lower Astoria basal sandstone and conglomerate, Province Cove, Port San Juan, Vancouver Island.
Distribution in fossil state: — Lower Astoria basal sandstone and conglomerate of Province Cove and Owens Point, Vancouver Island.

This questionable subspecies has been figured and described by the authors, but is said to be valid only if the specimens from the two localities are identical with one another. Most probably their doubted subspecies should be given another name.

Genus *Dallinella* Thomson, 1915

Dallinella occidentalis (Dall)
Type locality: — Off San Clemente Island, California.
Distribution: — California.
Distribution in fossil state: — Etchegoin formation of the Central Part of Kettlemen Hills (Upper *Mya* zone or Uppermost beds); Temescal Canyon, north of Santa Monica, Los Angeles County; Fulger point asphalt mine, near Gary. Upper Miocene to the Pleistocene of California. Questionably from the Vaqueros formation.

Dallinella obsoleta (Dall)
Type locality: — Northwest of Cerros Island, California, 58 fathoms.
Distribution: — Lower California.
Distribution in fossil state: — Astoria formation of Washington; Lincoln County Miocene, California.

Dallinella smithi (Arnold)
Type locality: — Pliocene of Deadman Island, California.
Distribution in fossil state: — Temescal Canyon, 3 miles north of Santa Monica, California; Etchegoin formation east of Zapato Creek (variable pebbly sand, *Pecten coalingaensis* zone or Upper Middle beds), two miles southwest of Coalinga (coarse sand and pebble conglomerate, same zone as former), Vicinity of Henry Spring (same zone as former). Also in the Suenomatuyama beds of Mutu province, Japan.

Genus *Dallina* Beecher, 1893

Dallina floridana (Pourtales)
Type locality: — Off Florida reefs, between 100-200 fathoms.
Distribution: — Off the Florida reefs, Gulf of Mexico, and West Indies.

Genus *Laqueus* Dall, 1870

Laqueus californicus (Koch)
Type locality: — California.

Distribution: — British Columbia to California.
Distribution in fossil state: — Pliocene of California.

Laqueus vancouverensis Davidson
Type locality: — Vancouver (?).
Distribution: — Southeast Alaska Peninsula to Washington.
Distribution in fossil state: — Pliocene of California.

Laqueus erythraeus Dall
Type locality: — Off Catalina Island, California, 80 fathoms.
Distribution: — Off Catalina Island, California.

Some generically questionable species

Terebratella (?) *sookensis* Clark and Arnold
Type locality: — Sooke basal sandstone, sea cliffs at the mouth of Fossil Creek, 2 miles west of Sherringham Point, Jordan River, Vancouver Island.
Distribution in fossil state: — Vancouver Island.

This species was described and figured; it apparently belongs to the genus *Diestothyris* according to the descriptive remarks and annexed illustrations. If it really is a *Diestothyris*, it strongly resembles the well known *D. frontalis* (Middendorff), mentioned in the foregoing lines.

Terebratula wilmingtonensis Lyell and Sowerby
Type locality: — Wilmington limestone of North Carolina.
Distribution in fossil state: — North Carolina Eocene.

This species closely resembles *Liothyrella uva* (Broderip), a recent species living in the Gulf of Tehuantepec, South Mexico (10-12 fathoms, type locality); Peru and Magellan district (18-600 fathoms), but is more narrow and appears to be somewhat higher. It shows "a development from smooth to an alternate multiplication or multicarination which may affect half the shell. It evidently belongs to a stock distinct from *Terebratula, Gryphus* and *Liothyrella*," according to Thomson.

Rhynchonella salpinx Dall
Type locality: — Eocene of Wilmington, North Carolina.
Distribution in fossil state: — North Carolina.

This is a peculiar rhynchonellid brachiopod resembling somewhat *Hemithyris sladeni* which is now known under the genus *Aetheia* of Thomson. Its characters are quite clear but it may probably belong to a new genus as already suggested by Thomson.

Rhynchonella holmesii Dall
Type locality: — Eocene of Wilmington, North Carolina.
Distribution in fossil state: — Unknown to the writer.

This species seems to belong to the genus *Tegulorhynchia* established by Chapman and Crespin, in the presence of radial ribbing at the margins of the shell. If it proves not to belong to it, then it as well as *R. salpix* Dall, may belong to a new genus, yet to be established.

Terebratula trinitatensis Guppy

T. carneoides Guppy

T. lecta Guppy

These three species were described upon material from the gypseous marls near San Fernando, Trinidad. Their shell outlines are fairly well seen in the figures given by Guppy, but precise accounts concerning their internal structure, type of folding and beak characters are necessary for a determination of their generic positions.

REFERENCE

ALDRICH, T. H. 1907—Some New Eocene Fossils from Alabama. Nautilus **21**:8-11, 1 pl.

ARNOLD, R. 1903—The Paleontology and Stratigraphy of the Marine Pliocene and Pleistocene of San Pedro, California. Mem. Calif. Acad. Sci. **3**:9-240, pl. 1-37.

———1907—New and Characteristic Species of Fossil Mollusks from the Oil-bearing Tertiary Formation of Santa Barbara, California. Smithsonian Inst. Misc. Coll. **50**(4):419-447, pls. 1-8.

———1907—New and Characteristic Species of Fossil Mollusks from the Oil-bearing Tertiary Formation in Southern California. Proc. U. S. Nat. Mus. **32**:525-546, pls. 38-51.

———1908—Descriptions of New Cretaceous and Tertiary Fossils from the Santa Cruz Mountains, California. Proc. U. S. Nat. Mus. **34**:345-389, pls. 31-37.

ARNOLD, R. AND R. ANDERSON. 1907—Geology and Oil Resources of Santa Maria Oil District, Santa Barbara County, California. Bull. U. S. Geol. Surv. **398**:1-161, pls. 1-24.

BEECHER, C. E. 1895—Revision of the Families of Loop-bearing Brachiopods and the Development of *Terebratalia obsoleta* Dall. Trans. Conn. Acad. Sci. Arts **9**(5-6):376-399, pls. 1-3.

BERRY, S. S. 1921—A New Neotreme Brachiopod from California. Ann. Mag. Nat. Hist. **8**:210-212, pl. 11.

BOIS, H. M. DU. 1916—Variation Induced in Brachiopoda by Environmental Conditions. Puget Sound Mar. Station, Univ. Washington, **1**:177-183.

CHAPMAN, F. AND I. CRESPIN. 1923—The Austral Rhynchonellacea of the "*Nigricans* series," with a special description of the new genus *Tegulorhynchia*. Proc. Roy. Soc. Victoria **35**:170-193, pls. 11-13.

CLARK, B. L. AND R. ARNOLD. 1923—Fauna of the Sooke Formation, Vancouver Island. Univ. Calif. Publ., Geol. Sci., **14**(5):176-177, pls. 32, 36.

CLARKE, W. B. AND G. C. MARTIN. 1901—Brachiopoda. In Maryland Geol. Surv., Eocene, 203-205, pl. 58.

CRICKMAY, C. H. 1925—A Pleistocene Fauna from the South-western Mainland of British Columbia. Canadian Field Nat. **39**(6):140-141.

DALL, W. H. 1871—Report on the Brachiopoda obtained by the United States Coast

Survey Expedition in charge of L. F. de Pourtales, with a Revision of the Craniidae and Discinidae. Bull. Mus. Comp. Zool. **3**(1):1-45, pls. 1-2.

———1873—Catalogue of the Recent Species of the Class Brachiopoda. Proc. Acad. Nat. Sci. Phila. 177-204.

———1889—A Preliminary Catalogue of the Shell-bearing Marine Mollusks and Brachiopods of the South-eastern Coast of the United States, etc. Bull. U. S. Nat. Mus. **37**:1-221, pls. 1-74.

———1895—Report on Mollusca and Brachiopoda Dredged in Deep Water, chiefly near the Hawaiian Islands, with Illustrations of Hitherto Unfigured Species from North-east America. Proc. U. S. Nat. Mus. **17**:675-733, pls. 22-32.

———1889—Preliminary Report on the Collection of Mollusca and Brachiopoda obtained in 1887-'88. Proc. U. S. Nat. Mus. **12**(773), Rep. No. 7.

———1902—Illustrations and Descriptions of New, Unfigured, or Imperfectly Known Shells, chiefly American in the U. S. National Museum. Proc. U. S. Nat. Mus. **24**:499-566, pls. 27-40.

———1903—Contributions to the Tertiary Fauna of Florida, with special reference to the Silex Beds of Tampa and the Pliocene Beds of the Caloosahatchie River. Trans. Wagner Free. Inst. Sci. **3**(6):1219-1654, pls. 49-60.

———1909—Contributions to the Tertiary Paleontology of the Pacific Coast. 1. The Miocene of Astoria and Coos Bay, Oregon. U. S. Geol. Surv., Prof. Paper **59**: 216 pp., 23 pls.

———1920—Pliocene and Pleistocene Fossils from the Arctic Coast of Alaska and the Auriferous Beaches of Nome, Norton Sound, Alaska. U. S. Geol. Surv. Prof. Paper **125**-C:23-37, pl. 5-6.

———1920—Annotated List of the Recent Brachiopoda in the Collection of the United States National Museum, with Descriptions of Thirty-Three New Forms. Proc. U. S. Nat. Mus. **57**(2314):261-377.

———1925—Illustrations of Unfigured Types of Shells in the Collection of the United States National Museum. Proc. U. S. Nat. Mus. **66**:1-41, pls. 1-36.

DAVIDSON, T. 1874—Note on Two Tertiary Species of Brachiopoda from the Island of St. Bartholomew, one of the North-eastern West Indian Islands. Geol. Mag., (2), **1**:158, pl. 8, figs. 11, 12.

———1886-1888—A Monograph of the Recent Brachiopoda. Trans. Linn. Soc. (2), **4**(1-3):1-248, pl. 1-30.

———1880—A Report on the Brachiopoda Dredged by H.M.S. Challenger, during the years 1873-1876. Voy. Challenger, Zool. **1**:67 pp., 4 pls.

ELDRIDGE, G. H. AND R. ARNOLD. 1907—Santa Clara Valley, Puente Hills and Los Angeles Oil District, in Southern California. U. S. Geol. Surv. Bull. **309**.

GARDNER, J. 1925—A New Midway Brachiopoda, Butler Dome, Texas. Amer. Jour. Sci. **10**(5):134-138, 8 figs.

HATAI, K. 1936—The Geographic Distribution of Brachiopoda. Parts 2-3. Recent Brachiopoda of Foreign Countries. Bull. Biogeogr. Soc. Jap., **6**(10):75-95.

———1936—A Synopsis of the Recent and Fossil Rhynchonellid Brachiopoda. Bull. Biogeogr. Soc. Jap. **6**(20):197-205.

———1936—Fossil Brachiopoda from the Ninohe District, Mutu Province. Jap. Jour. Geol. Geogr. **13**(1-2):71-83, 1 pl.

———1937—A Note Concerning the Distinctive Features Between Certain Brachiopoda Genera. Bull. Biogeogr. Soc. Jap. **7**(5):57-61.

———1937—Occurrence of the Brachiopoda Genus *Macandrevia* in Japanese Neogene. Bull. Biogeogr. Soc. Jap. **7**(9):165-167.

HERTLEIN, L. G. AND C. H. CRICKMAY. 1925—A Summary of the Nomenclature and Stratigraphy of the Marine Tertiary of Oregon and Washington. Proc. Amer. Philos. Soc. **64**(2).

GUPPY, R. J. L. 1866—On Tertiary Brachiopoda from Trinidad. Quart. Jour. Geol. Soc. **22**:295-297, 1 pl.

KELSEY, F. W. 1907—Mollusks and Brachiopods collected in San Diego, California. Trans. San Diego Soc. Nat. His. **1**(2).

LYELL, C. 1845—Observations on the White Limestone and other Eocene or older Tertiary Formations of Virginia, South Carolina and Georgia. Quart. Jour. Geol. Soc. **1**:429-442.

MARTIN, G. C. 1904—Brachiopoda. In Maryland Geol. Surv., Miocene, 402-404, pl. 109, figs. 1-3.

MORSE, E. S. 1902—Observations on Living Brachiopods. Mem. Boston Soc. Nat. Hist., **5**(8):313-386, pl. 39-61.

NOMURA, S. AND K. HATAI. 1937—A List of the Northwest Cenozoic Brachiopoda contained in the Division of Geology of the Saito Ho-on Kai Mus. Res. Bull. **13**:179-188, 1 pl.

SCHUCHERT, C. 1897—A Synopsis of American Fossil Brachiopoda, including Bibliography and Synonymy. U. S. Geol. Surv. Bull. **87**:464 pp.

———1911—Palaeographic and Geologic Significance of Recent Brachiopoda. Bull. Geol. Soc. Amer. **22**:259-275.

———1913—Brachiopoda. In Eastman-Zittel, Text-Book of Palaeontology **1**:355-420.

THOMSON, J. A. 1927—Brachiopod Morphology and Genera (Recent and Tertiary). New Zealand Board of Sci. and Art, Manual **7**:1-338, pl. 1-2.

WHITFIELD, R. P. 1894—Mollusca and Crustacea of the Miocene Formations of New Jersey. U. S. Geol. Surv. Monogr. **24**:23,24, pl. 1, figs. 1-3.

INSTITUTE OF GEOLOGY AND PALEONTOLOGY,
TOHOKU IMPERIAL UNIVERSITY,
SENDAI, JAPAN.

Pentameridae of the Cedar Valley Beds of Iowa

Merrill A. Stainbrook

Gypidula and *Pentamarella* are the only pentamerid genera that occur in the Cedar Valley formation. Individually and specifically they are sparsely represented as compared with either *Atrypa* or *Stropheodonta*. Their species, however, are among the more distinctive index fossils. The middle portion of the Littleton substage has two characteristic forms of *Pentamarella* and has been designated the pentamarella zone.

Two peculiarities in stratigraphic distribution of these genera are notable. *Gypidula* is confined to the basal Independensis zone of the Cedar Valley, but appears in moderate numbers in the succeeding Devonian formations of the State. *Pentamerella* occurs in every zone of the formation but as yet has not recovered from superadjacent beds.

Superfamily PENTAMERACEA Schuchert

Family *Pentameridae* McCoy

Subfamily *Gypidulinae* Schuchert and Levene

Genus *Gypidula* Hall

Gypidula comis (Owen)

Pl. 1, Figs. 7-12

Atrypa comis Owen, Rep. Geol. Surv. Wis., Iowa and Minn. : 583, Tab. 3A, fig. 4, 1852.

Pentamerus (N.Sp.) Owen, Ibid. Tab. 3A, fig. 11, 1852.

Pentamerus galeatiformis Meek and Worthen, Geol. Surv. Ill. 2: 325, 1866.

Pentamerus comis Meek and Worthen, Geol. Surv. Ill. 3: 428, pl. 13, fig. 6, 1868; Whiteaves, Contrib. Can. Pal. 1: 290, 1892.

Gypidula comis Schuchert, Bull. 87, U.S.G.S.: 226, 1897; Belanski, Univ. Iowa Studies Nat. Hist. 12, (7): 9-11, fig. 3, pl. 1, figs. 1-11, 1928.

Description.—Shell strongly but unequally biconvex, subtriangular, a little longer than wide, broadest anterior to the midlength, smooth except anteriorly. Dimensions of three hypotypes: length 24.4 mm., 23.1 mm. and 22.8 mm.; width 22.8 mm., 22.7 mm. and 23.1 mm.; thickness 18.6 mm., 17.8 mm. and 17.6 mm.

Pedicle valve much the larger and more convex, strongly arched from beak to front with the curve posteriorly recumbent, strongly arched from side to side, prominent and somewhat laterally compressed in the umbonal region. Fold broad, low, short, limited to the anterior part of the valve and somewhat truncate marginally by the extension of the opposite sinus; it bears 3 or 4 short broadly rounded plications which lie anterior to the midlength. On each lateral slope are 3 or 4 shorter but similar plications. Beak large, pointed, strongly incurved over and beyond that of the brachial valve. Cardinal area triangular, wider than high, strongly curved, about one-third as wide as the

shell and indistinctly defined marginally. Delthyrium moderately high. Internally, there is a thin low median septum extending anteriorly a short distance from the beak. It supports an inverted V-shaped spondylium which reaches the middle of the shell, where it approaches the brachial cruralium.

Brachial valve gently convex, highest in the umbonal region whence the surface slopes abruptly to the hingeline; strongly arched from beak to front but gently so transversely, slightly concave on the lateral slopes of some specimens. A broad sinus originates at the midlength and continues as a linguiform extension deflected almost at right angles to the plane of the valve. Beak prominent, short, incurved. Most of valve smooth; 3 short rounded plications occupy the anterior part of the sinus and the same number appears on the margin of each slope. Cross sections of the interior show that the short hingeplate is divided beneath the beak by a crural cavity. The inner crural plates which arise immediately from the hingeplate are moderately wide, divergent from each other and thicken distally. The outer crural plates sup-

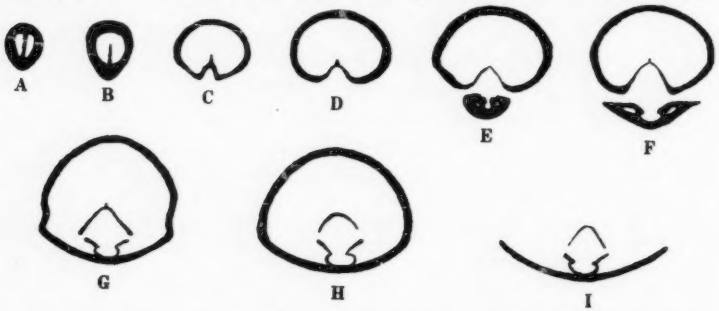


Fig. 1. A series of nine cross-sections of the rostral portion of the shell of *Gypidula comis* (x1.25) showing the short median septum and the spondylium of the pedicle valve and the sessile trough in the brachial valve.

porting them are concave toward the middle of the valve, are several millimeters high and join the floor of the valve at a low angle to form a broad sessile trough which extends forward beyond the midlength.

Remarks.—*Gypidula comis* is distinguished by its large size, by the long and high umbonal region of the pedicle valve and by the narrow deep brachial sinus.

Belanski's sections of the interior of a specimen from Solon, Iowa, show the inner plates of the brachial valve to be horizontal with distal descending portions nearly reaching the spondylium. The accompanying series of sections shows the inner plates to be differently shaped and to be directed upward to the spondylium. Several additional specimens of *G. comis* from various localities were sectioned and in each of these, the inner plates were formed as illustrated. This difference may be due to varying modes of procedure, to personal interpretation or to the native variability of the species.

Reference of this species by Hall, and Hall and Clark actually pertain to several species; localities given by them for some of their specimens are erroneous and it is doubtful if they examined any examples of true *Gypidula comis*.

Occurrence.—Cedar Valley limestone, in the lower part of the Independensis zone, at Solon, Davenport, Buffalo, Atalissa, and Independence, Iowa; Rock Island, Ill.

Holotype.—U.S. National Museum, no. 17928.
Paratype.—17929.
Hypotypes.—St. Univ. Iowa no. 6-194 and M.A.S. 192, 193, 223, 257.

Gypidula occidentalis Hall
Pl. 1, Figs. 1-6

Pentamerus occidentalis Hall, Geol. of Iowa, 1, (2): 514, pl. 6, figs. 2 a, b, c, 1858. (Not *Pentamerella occidentalis* Hall, Pal. N. Y. 2: 341, pl. 79, figs. 1, 2-s, 2, 1852.)

Gypidula occidentalis Hall, Pal. N. Y. 4: 380, pl. 58A, figs. 1-5, 8, (not 6 or 7): Belanski, Univ. Iowa Studies Nat. Hist. 12, (7): 7, fig. 2, pl. 2, figs. 1-8., 1928.

Gypidula comis Walcott, U.S.G.S. mono. 8: pl. 3, fig. 4, (not fig. 7) 1884; Hall and Clarke, Pal. N. Y. 8, (2): 247, fig. 177, 248, pl. 72, figs. 18-20, (not figs. 15-17, nor figs. 21-24), 1894.

Gypidula laevis Hall and Clarke, Pal. N. Y. 2: pl. 72, figs. 22-23, 1893.

Description.—Shell small, subtriangular, subequally biconvex, slightly wider than long, widest anterior to the midlength. Measurements of a hypotype: length, 18 mm.; width, 21 mm.; thickness, 13 mm.

Pedicle valve much longer than the brachial, moderately arched along the midline but more strongly so posteriorly, strongly arched from side to side, highest in the prominent and narrow umbonal region whence the surface curves abruptly to the cardinal margins and evently and less rapidly to the lateral margins. Fold low and broad, present only in mature specimens, originating anterior to the midlength, and occupied by 3 short rounded to angular plications. On each lateral slope of adult shells are 3 or 4 similar but shorter plications: those nearest the fold are slightly longer. Beak large, pointed, incurving and extended beyond the umbo of the valve. Cardinal area low, concave, wider than high, indistinctly defined at the sides. Delthyrium of moderate size, narrow. Internally a median septum extends a short distance from the beak anteriorly and supports the spondylium which is continued beyond to the middle of the shell.

Brachial valve gently convex, highest in the umbonal region, arched from beak to front but more strongly so over the umbo, gently arched transversely with the curvature becoming concave near the lateral margins. Sinus broad, shallow, limited to the anterior third of the valve, strongly deflected and extended at the front, truncating the opposite part of the pedicle valve; occupied in mature specimens by two short rounded plications. Each lateral slope flexed at the margin by 2 short plications. Beak short, rounded, and extending

a short way beyond the hingeline. Internally the hingeplate is short and speedily gives rise to the inner crural plates which are thin, narrower toward the front and divergent from their bases. The outer crural plates are wider

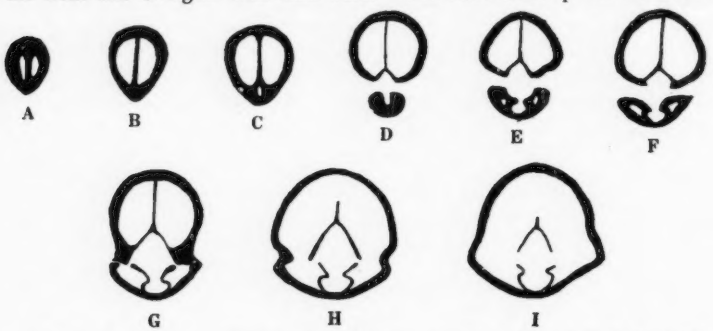


Fig. 2. A series of nine cross-sections of the rostral portion of the shell of *Gypidula occidentalis* (x1.25) showing the internal structures. The septum of the pedicle valve is notably longer than in *G. comis*.

than the inner plates; are strongly convex outwardly and join the floor of the valve at an angle of 45 degrees. They are separated at the bases by a space equal to their height and form a sessile trough extending forward beyond the midlength.

Surface of both valves smooth, marked by faint concentric striae of growth and an occasional stronger one.

Remarks.—*Gypidula occidentalis* was originally described by Hall from shells collected at Independence and his illustration in Geology of Iowa 1 (2), shows only a pedicle valve. In the American Museum of Natural History, however, a complete specimen, not the one illustrated in the *Geology of Iowa,* is marked as the type. *Gypidula occidentalis* can be distinguished from *Gypidula comis* by its smaller size, by being wider than long, by having a less prominent and less extended umbo, by its less convex shell, by its wider and shallower sinus, and by the concavity of the brachial valve near the lateral margins. Internally the crural inner plates of *Gypidula occidentalis* are higher, the outer plates narrower, and the median septum of the pedicle valve is continued forward farther than is the case in *Gypidula comis*. The form, to which Hall and Clark provisionally gave the name *Gypidula laevis,* is retained in this species until more and better specimens than those we have at hand may be secured.

Occurrence.—Cedar Valley limestone in the upper part of the Independensis zone, at Independence, Linn Junction, Waverly, Troy Mills, and Solon, Iowa. As noted by Belanski, this species occurs mainly in the north portion of the Cedar Valley area of Iowa. It has been collected, however, as far south as Solon above beds containing *G. comis*.

Hypotypes.—S.U.I nos. 6-192, 6-193, and M.A.S. 41, 50B, 257, 192, 193

Genus *Pentamerella* Hall
Pentamerella dubia Hall
Pl. 2, Figs. 3-9

Atrypa (n. sp.?) Owen, Geol. Surv. Wis., Iowa, and Minn.: pl. 3A, fig. 1, 1852.

Spirifer dubius Hall, Thirteenth Rep. N. Y. St. Cab. Nat. Hist.: 90, 1860.

Pentamerella dubia Hall, Pal. N. Y. 4: 379, pl. 58, figs. 38-43, 1867; Hall and Clarke, Pal. N. Y. 8, (2): 245, pl. 71, figs. 32-35, not figs. 36-38, 1893.

Pentamerella micula Hall, Pal. N. Y. 4: 378, pl. 58, figs. 26-27, 1867; Hall and Clarke, Pal. N. Y. 8, (2): 245, 1893.

Description.—Shell subovate to subtriangular, strongly and unequally biconvex, longer than wide, broadest anterior to the midlength. Measurements of a hypotype: length, 20.5 mm.; width, 18.9 mm.; thickness, 13.8 mm.

Pedicle valve much the longer, strongly convex and extended in the umbonal region, highest posterior to the midlength, the surface sloping abruptly to the postero-lateral and cardinal margins and strongly to the lateral margins. Sinus originating well up on the umbo, moderately deep, deepening and widening toward the front, flattened at the bottom, defined at each side by a strong plication, occupied throughout by 3 or 4 strong angular plications. Lateral slopes bearing 8 to 10 similar plications, shorter and weaker than those in the sinus and decreasing in size and length toward the cardinal angles. Beak large, pointed, strongly extended, incurving over and beyond the brachial beak. Area moderately high, curved, poorly defined at the sides, marked by transverse growth striae; delthyrium large, higher than wide. Surface usually smooth in the umbonal region but marked elsewhere by numerous strong lamellose lines of growth which may be so strong as to interrupt the continuity of the plications and to be impressed on the interior of the valve. Inter-

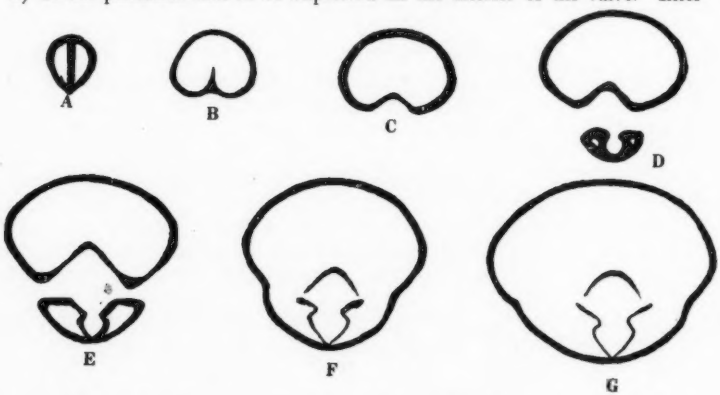


Fig. 3. A series of seven cross-sections of the rostral portion of the shell of *Pentamerella dubia* (x2.5) showing the short median septum and the spondylium of the pedicle valve and the lightly sessile cruralium of the brachial valve.

nally there is an extremely short median septum in the beak of the valve. The spondylium rises gradually from the hingeplate and extends forward beyond the midlength to a position near the middle of the shell.

Brachial valve gently to strongly convex, much wider than long, highest near the midpoint; the surface curving strongly from the umbo to the postero- and antero-lateral margins and less strongly to the lateral. Fold originating on the umbo, increasing in height and width toward the front, flattened, defined at either side by a broad deep furrow, bearing on the average 4 or 5 strong angular plications. On each lateral slope are from 8 to 10 similar plications which decrease in size and height toward the cardinal angles. Beak stout, extended and incurving. Growth lamellae as on the opposite valve. Internally the cruralium is large, attached to the floor throughout its length; inner plates wide and divergent; the outer plates concave outwardly near their distal extremities, and united at their junction with the floor of the valve.

Remarks.—*Pentamerella dubia* is easily distinguished from *Pentamerella subarata* by its more numerous and smaller plications. From *Pentamerella rugosa* it differs in having a more extended umbonal region in the pedicle valve and shorter, stouter plications and a stronger fold and sinus. Specimens of the form described by Hall as *Pentamerella micula* seem only to be small examples of *Pentamerella dubia*. Additional specimens must be secured before the distinctness of the two species can be recognized definitely.

Occurrence.—Cedar Valley limestone in the *Cranaena iowensis* zone at Iowa City, Linder's Boathouse, Rapid Creek, and Robert's Ferry in Johnson County, Iowa.

Holotype.—American Museum of Natural History.

Hypotypes.—S.U.I. no. 6-190; M.A.S. nos. 97, 291, 292, and 293.

Pentamerella magna sp. nov.

Pl. 1, Figs. 13-20

Description.—Shell large, strongly but subequally biconvex, subtriangular to subovoid with the cardinal angles rounded, about as wide as long with the greatest width anterior to the midlength. Measurements of the holotype and of a paratype: length, 24.2 mm. and 21.1 mm.; width, 25.5 mm. and 20.8 mm.; thickness, 16.1 mm. and 13.7 mm. A larger pedicle valve measures 35 mm. in length and width.

Pedicle valve highly arcuate with the umbonal region strongly convex and extended, the surface arching strongly from the umbo with even rapid curvature to the anterior and anterolateral margins. Beak blunt, incurving, and

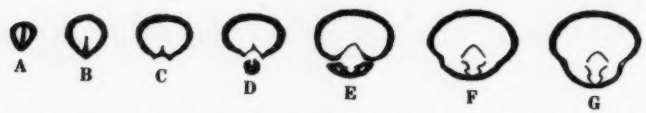


Fig. 4. A series of seven cross-sections of the rostral portion of the shell of *Pentamerella magna* (x1) showing the internal structures.

extending over and beyond that of the opposite valve. Area small, concave, triangular, wider than high and marked by several wrinkles of growth; delthyrium moderately large, wider than high. Sinus shallow, broadly convex at the bottom, deepest along the sides, originating well up on the umbo, widening toward the front and forming a linguiform extension there. Internally a short stout median septum in the rostral portion of the valve supports the spondylium which is continued on beyond to the middle of the shell.

Brachial valve much the shorter, moderately convex, with the greatest convexity in the umbonal region, the surface curving gently from the umbo to the lateral margins and sloping with moderate rapidity to the cardinal and anterolateral margins. Beak fairly large, pointed and projecting. Fold extending well up on the umbo, wider and higher anteriorly, broad and flattened. Internally a V-shaped cruralium extends from the beak anteriorly almost to the midpoint and is attached to the floor of the valve at the junction of the lamellae.

The surface of both valves is smooth in the umbonal regions. Plications low, rounded, narrow, and variable in length; in some specimens extending upon the umbo and in other confined to the anterior portions of the valves. The number ranges from 26 to 30; 6 to 9 plications in the sinus or on the fold and from 8 to 10 on each lateral slope. Concentric striae of growth not uncommon, occasionally near the front the plications are interrupted by deep wrinkles which are reflected on the interior of the valves.

Remarks.—This species is the largest *Pentamerella* recovered from the Devonian strata of the State. It is easily distinguished by its large size and by the large number of subequal rounded plications of moderate length.

Occurrence.—Cedar Valley limestone, in the pentamerella zone at Brandon, and as far as known confined to that vicinity.

Holotype.—S.U.I. no. 6-197a.

Paratypes.—S.U.I. nos. 6-197b, c, d; M.A.S. nos. 103, 104, 107 and 117.

Pentamerella rugosa sp. nov.

Pl. 2, Figs. 31-34

Description.—Shell subtriangular to subpentagonal in outline with rounded antero-lateral margins, moderately but unequally biconvex, a little wider than long, broadest at the midlength. Measurements of the holotype (a pedicle valve) and of a paratype (a brachial valve): length, 19 mm. and 14 mm.; width, 22 mm. and 19 mm. A complete paratype measures 17.4 mm. in length, 18.8 mm. in width and 11.1 mm. in thickness.

Pedicle valve moderately convex, elongated in the umbonal region, arched from beak to front with the greatest curvature over the umbo, the surface curving rapidly and evenly from the beak to the front and lateral margins and sloping abruptly to the hingeline. Beak blunt and incurving; area of moderate height, concave, and indistinctly defined laterally; delthyrium higher than wide. Mesial sinus originating at the beak, shallow, gently convex at the bottom, a little deeper along the sides and indistinctly defined from the rest

of the valve. Internally a short median septum is visible beneath the beak. The short spondylium extends nearly to the center of the shell.

Brachial valve gently convex with the greatest convexity in the umbonal region when the surface slopes with even gentle curvature to the anterior and lateral margins and more abruptly to the cardinal margins. Beak small and scarcely projecting. Fold extending from beak to front, low, flattened, broadly convex. Interior unknown.

Plications sharply convex, narrow, separated by furrows of lesser width, increasing by dividing several times, extending from the margins to the beak of each valve, and numbering from 7 to 9 in the sinus or on the fold and from 13 to 15 on each lateral slope. Several prominent growth lines interrupt the continuity of the plications in most specimens; between them are numerous finer growth striae.

Remarks.—The specimens at hand are more or less crushed and with two exceptions are separate valves. Several are embedded in the tough limestone and are difficult to remove with the shell intact. A pedicle valve has been selected as the holotype but many of the characters noted in the description are seen only in other specimens. *Pentamerella rugosa* is readily identified by the large number of rather fine plications which extend well up on the beaks.

Occurrence.—Cedar Valley limestone, in the Pentamerella zone with the preceding form at Brandon, Littleton, and Solon, Iowa.

Holotype.—M.A.S. 113.

Paratypes.—M.A.S. 115, 279 and S.U.I. no. 6-191.

Pentamerella subarata sp. nov.

Pl. 1, Figs. 21-24; Pl. 2, Figs. 1-2

Pentamerella arata Hall, New York 4. pl. 58, figs. 20,21, not figs. 1-19, 1867; Hall and Clarke, New York, 8, pt. 2, pl. 71, fig. 29, not figs. 21-28, 1893.

Description.—Shell oval, moderately but unequally biconvex, a little longer than wide with the greatest width anterior to the midlength. Dimensions of the holotype and of a paratype: length, 23.7 mm. and 19.2 mm.; width, 21.8 mm. and 19.2 mm.; thickness, 15.1 mm. and 13.3 mm.

Pedicle valve much the longer, strongly convex with the greatest convexity in the umbonal region, the surface sloping with equal and rapid curvature from the midpoint to the antero-lateral margins but more abruptly to the postero-lateral margins. The shallow sinus extends from beak to front and is

Fig. 5. A series of seven cross-sections of the rostral portion of the shell of *Pentamerella subarata* (x1) showing the short median septum of the pedicle valve and the delicate spondylium and cruralium.

chiefly distinguished from the remainder of the valve by the larger and deeper furrows at the sides. Beak prominent, extended, and strongly incurved over that of the opposite valve. Cardinal area small, curving, with indistinct lateral margins; delthyrium small. Internally the median septum is short and confined to the rostral portion of the valve; the delicate spondylium is continued on beyond to the center of the shell where it approaches the brachial cruralium.

Brachial valve subcircular in outline, moderately convex, highest in the umbonal region. Mesial fold broad, low, extending from beak to front, usually indicated by its prominent plications and defined at the sides by deep broad furrows. Beak small, scarcely projecting. Internally there is a narrow sessile V-shaped cruralium extending anteriorly for half the length of the valve; the moderately high crural outer plates are strongly curved toward the interior of the shell and are united at their junction with the floor of the valve.

Surface of each valve marked by strong, broad angular to rounded plications, usually simple but occasionally divided near the lateral or front margins. They extend from the margins to the beak and average from 8 to 12 in number, 3 on the fold or in the sinus and 3 or 4 on each lateral slope. Fine concentric striae are common on well preserved specimens.

Remarks.—This species in the county reports issued by the Iowa Geological Survey usually has been listed as *Pentamerella arata* (Conrad). Hall illustrates a small brachiopod from Waterloo in the Paleontology of New York, vol. 4, under this name and judging from the illustration it is a small example of *Pentamerella subarata*. *Pentamerella arata* is much larger than *P. subarata*, shows more variation in size and number of the plications, and occurs at a much lower horizon.

Occurrence.—Cedar Valley limestone, in the profunda zone at Brandon, Waterloo, Littleton, and Vinton, Iowa.

Holotype.—S.U.I. no. 6-196.

Paratypes.—S.U.I. no. 6-409 and M.A.S. nos. 40 and 85.

Pentamerella cf. *multicostata* Cleland

Pl. 2, Figs. 27-30

Pentamerella multicostata Cleland, Wis. Geol. and Nat. Hist. Surv. Bull. 21: 94, pl. 18, fig. 18, 1911.

Description.—Shell small, subequally biconvex, subovate, rounded at the front, longer than wide, broadest anterior to the midlength. Measurements of a hypotype: length, 17.8 mm.; width, 16.6 mm.; thickness, 10.3 mm.

Pedicle valve much longer than the brachial, arching with increasing curvature over the umbo, strongly convex with the greatest convexity posterior to the midlength, the surface sloping rapidly and evenly to the antero-lateral margins and abruptly to the cardinal margins. Sinus very shallow, originating near the midlength, indistinctly defined at the sides and extended a little at the front. Beak small, pointed, curving and projecting over and beyond that

of the brachial valve. Cardinal area moderately high, curved, poorly defined at the sides; delthyrium higher than wide.

Brachial valve transversely ovate, wider than long, gently convex, highest in the umbonal region whence the surface curves gently to the antero-lateral margins and more rapidly to the hingeline. Fold broad, low, flattened, indistinctly separated from the lateral slopes and originating at the midlength. Beak small, projecting.

Surface of both valves smooth in the umbonal region, marked elsewhere by strong simple plications, numbering 3 on the fold and in the sinus and 6 on each lateral slope; the furrows between are distinctly wider and are broadly rounded at the bottom. Numerous fine concentric striae of growth cross the plications and furrows.

Remarks.—The type specimen of *Pentamerella multicostata,* which was not seen by us, is an internal mold. Ours are complete shells and reference of our Iowa form to this species is only provisional. However, the specimens at hand are similar in size, shape, and markings as shown by the illustrations and follow closely the description given by Cleland. It therefore has seemed best to consider the two forms as identical until further study.

Pentamerella multicostata is readily separable from *Pentamerella rugosa* by its smaller size, by the smaller number of simple and more angular plications and by the less distinct fold and sinus. From *Pentamerella dubia* it differs in possessing a less gibbous shell, simple plications of less number, a less pronounced beak, and by the fainter fold and sinus. The small size, different shape, and the length and angularity of the plications readily separate this species from *Pentamerella magna.*

Occurrence.—Cedar Valley limestone in the Independensis zone at Independence, Solon, and Davenport, Iowa. Originally described from Milwaukee, Wisconsin.

Hypotypes.—S.U.I. nos. 6-409 and 6-195.

Pentamerella laeviuscula (Hall)

Pl. 2, Figs. 21-24

Gypidula laeviuscula Hall, Pal. N. Y. 4: 381, pl. 58, figs. 22, 23, 1867; Hall and Clarke, N. Y. 8, pt. 2: 248, pl. 72, figs. 25, 26, 1893; Schuchert, Bull. 87, U.S.G.S.: p. 226, 1897; Belanski, Iowa Studies in Nat. Hist. 12 (7), 18, pl. 1, figs. 25-27, 1928.

Description.—Shell small, subequally biconvex, transversely subovate, wider than long with the greatest width anterior to the midlength. Measurements of two hypotypes: length, 8.2 mm. and 9.1 mm.; width, 9.5 mm and 10.7 mm.; thickness, 6.1 mm. and 6.7 mm. A larger specimen, presumably of this species, measures 13 mm. in length, 13.3 in width, and 9.5 in thickness.

Pedicle valve convex, arched from beak to front, most strongly so posteriorly, highest in the umbonal region whence the surface curves uniformly and rapidly to the antero-lateral margins and abruptly to the cardinal margins, moderately arched from side to side. Sinus obsolete or confined to the extreme

anterior portion where it is defined by a short shallow furrow on either side. Umbonal region prominent, a little projecting beyond the hingeline. Beak small, short, incurved; area small, scarcely defined at the sides. Plications represented by faint flexures wholly confined to the margin of the valve, numbering 2 or 3 in the sinus and 2 on each lateral slope. Remainder of the valve smooth and marked by numerous fine concentric striae of increment.

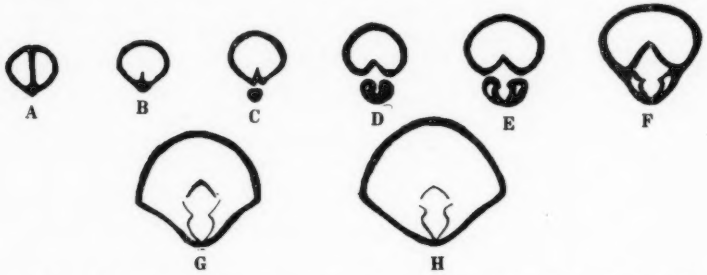


Fig. 6. A series of eight cross-sections of the rostral portion of the shell of *Pentamerella laeviuscula* (x2.5) showing the short median septum and the spondylium of the pedicle valve and the harp shaped cruralium which is barely attached to the brachial valve. The latter character places the species in the genus *Pentamerella*.

Brachial valve a little shorter than the pedicle, moderately convex, highest in the umbonal region whence the surface slopes with an even gentle curve anteriorly and laterally, and abruptly to the cardinal margins. Beak blunt, incurving, projecting. Fold very low, broad, confined to the extreme front of the valve, indistinctly defined at the sides by gentle flexures, bearing 3 or 4 extremely short, low, broad plications. Confined to the margins of each lateral slope are from 1 to 3 very faint plications. Remainder of the valve marked by faint concentric growth lines.

Remarks.—The small size, smoothness of the shell, and nearly obsolete fold, sinus and plications separate this form from larger species. From *Pentamerella obsolescens, Pentamerella laeviuscula* mav be distinguished by its less thick shell, greater transversity, and more nearly obsolete fold, sinus and plications.

Hall gives seven-eights of an inch as the length of *Pentamerella laeviuscula*, probably incorrectly. The type specimen is only about three-eights of an inch long as are the specimens which we have thus far recovered. The illustration given by Hall also does not indicate such magnitude. Internal sections show this form to be a *Pentamerella*.

Occurrence.—Cedar Valley limestone, in the profunda zone at Waterloo, Brandon, Littleton, and Vinton. *Cranaena iowensis* zone at Iowa City and elsewhere in Johnson County.

Holotype.—American Museum of Natural History no. 4199.

Hypotypes.—S.U.I. nos. 6-211, 6-415, 6-200 and M.A.S. no. 294.

Pentamerella obsolescens Hall
Pl. 2, Figs. 25-26

Pentamerella obsolescens Hall, Pal. N. Y. 4: 379, pl. 58, figs. 24, 25, 1867; Hall and Clarke, Pal. N. Y. 8, pt. 2: 245, 1895; Schuchert, Bull. 87, U.S.G.S.: 303, 1897.

Description.—Shell small, subpentagonal, strongly but unequally biconvex, gibbous, subspherical, a little wider than long, broadest near the midlength. Measurements of two hypotypes: length, 8.5 mm. and 9.4 mm.; width, 9.5 mm. and 10 mm.; thickness, 7.6 mm. and 7.4 mm.

Pedicle valve strongly convex, highest in the umbonal region whence the surface slopes rapidly and evenly to the lateral and front margins and abruptly to the hingeline. Mesial sinus obsolete in some specimens, indicated in others by an extremely shallow depression and slight extension of the median anterior portion of the valve; occupied by 3 or 4 low, narrow, rounded, very short, simple plications. Lateral slopes marked by 2 or 3 similar but shorter plications, sometimes indicated only by gentle flexures of the margin of the valve. Beak moderately large, incurving, and projecting a little beyond that of the brachial valve; cardinal area low, small, indistinctly limited at the sides, usually concealed by the beak. Internally the median septum is very short and confined to the beak. Spondylium strongly developed and extending to the center of the shell.

Fig. 7. A series of six cross-sections of the rostral portion of the shell of *Pentamerella obsolescens* (x2.5) showing the short median septum and the spondylium of the pedicle valve and the erect cruralium of the brachial valve.

Brachial valve a little shorter than the pedicle, strongly convex, the point of greatest convexity a little posterior to the midlength whence the surface curves evenly and rapidly to the front and lateral margins and strongly to the postero-lateral margins. Fold broad, very low, originating a short distance behind the anterior margin, poorly defined at the sides, almost obsolete in some specimens and indicated generally by faint flexures at the front margin. Umbo prominent, beak short, pointed, projecting, a little incurved. Plications similar to those of the opposite valve, variable in strength, confined to the margins in some specimens and several millimeters long in others, numbering about 4 on the fold and 2 or 3 on each lateral slope. Internally the cruralium is similar in appearance to that of other members of the genus.

Remarks.—*Pentamerella obsolescens* is readily separated from the other *Pentamerellas* of the Cedar Valley by its small size, strongly biconvex shape, and general obsolescence of the plications, fold and sinus. From *Pentamerella laeviuscula* it differs in having a more gibbous shell, and stronger fold, sinus and plications.

Occurrence.—Cedar Valley limestone. Originally described from the profunda zone at Waterloo, also occurs at Brandon, Jesup, and Vinton, Iowa. A similar form occurs in the *Cranaena iowensis* zone at Iowa City, Robert's Ferry, and elsewhere in Johnson County, Iowa.

Holotype.—American Museum of Natural History no. 4198.

Hypotypes.—S.U.I. no. 6-212, 6-225 and M.A.S. no. 56.

Pentamerella nitida sp. nov.

Pl. 2, Figs. 13-20

Description.—Shell broadly subtriangular with rounded antero-lateral margins, subequally biconvex, much wider than long with the greatest width anterior to the midlength. Measurements of the holotype and of two paratypes: length, 13.7 mm., 13.8 mm., and 14.5 mm.; width, 16.1 mm., 17 mm., and 16.7 mm.; thickness, 9.2 mm., 10.1 mm., and 9.6 mm.

Pedicle valve strongly convex, highest anterior to the umbo whence the surface curves evenly and strongly to the front and lateral margins and more rapidly to the cardinal margins. Sinus broad, very shallow, distinguished chiefly at the front margin and poorly defined at the sides. Umbonal region prominent but not greatly projecting beyond the hingeline. Beak small, short, pointed, a little incurved over that of the opposite valve. Area wider than high, curved and divided by the delthyrium which is about as wide as high. Internally the median septum is very short and confined to the rostral portion of the beak; the spondylium is strongly developed and continues to the center of the shell.

Brachial valve shorter than the pedicle and less convex, transversely subelliptical, gently elevated in the umbonal region. Fold broad, low, flattened, extending posteriorly from the front margin less than half the length of the valve. Internally the cruralium is similar in appearance to that in other members of the genus.

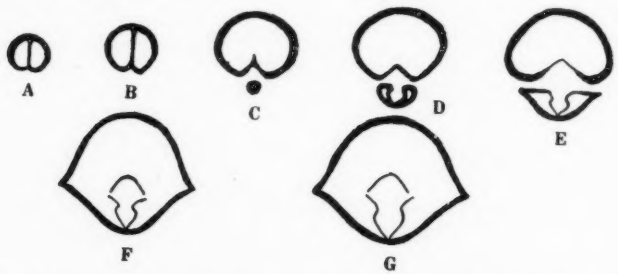


Fig. 8. A series of seven cross-sections of the rostral portion of the shell of *Pentamerella nitida* (x2.5) showing the internal structure of the species.

Surface of both valves smooth in the umbonal region, marked laterally and anteriorly by from 25 to 28 narrow, rounded, radiating plications which extend posteriorly a little more than half the length of the shell. Fold and sinus each occupied by about 6 simple plications and each lateral slope by about 10 which decrease in length and size toward the cardinal angles. Concentric striae of increment numerous and occasionally strongly developed.

Remarks.—*Pentamerella nitida* differs from *Pentamerella dubia* in the smaller size, more transverse shell, lack of lamellose growth lines, less prominence and protuberance of the umbonal region and weaker fold and sinus. The shortness in comparison with the length, the delicacy of the plications, and the smooth appearance of the shell will separate this from from *Pentamerella rugosa* and *Pentamerella multicostata.*

Occurrence.—Cedar Valley limestone in the *Cranaena iowensis* zone at Iowa City, Robert's Ferry, Catfish Camp, Lost Creek, and Linder's Boathouse in Johnson County, Iowa.

Holotype.—M.A.S. no. 194.

Paratypes.—S.U.I. nos. 6-202, 6-201, 6-207, 2-412.

PLATE 1

FIGURES

1–6. *Gypidula occidentalis* Hall. 1-4. Pedicle, brachial, anterior and lateral views of a homeotype from Independence, Iowa, (M.A.S. 41). 5-6. Pedicle and brachial views of a hypotype from Waverly, Iowa, (M.A.S. 193).

7–12. *Gypidula comis* (Owen). 7-8. Pedicle and brachial views of a hypotype from Randalia, Iowa, (M.A.S. 250). 9-12. Pedicle, brachial, anterior and lateral views of a hypotype, Solon, Iowa, (S.U.I. 6-194).

13–20. *Pentamerella magna* sp. nov. 13-16. Pedicle, brachial, posterior and lateral views of a paratype. 17-20. Pedicle, brachial, anterior and lateral views of the holotype. Both from Brandon, Iowa, (S.U.I. 6-197a).

21–24. *Pentamerella subarata* sp. nov. Pedicle, brachial, anterior and lateral views of the holotype, Littleton, Iowa, (S.U.I. 6-196).

(All figures are natural size.)

PLATE 1

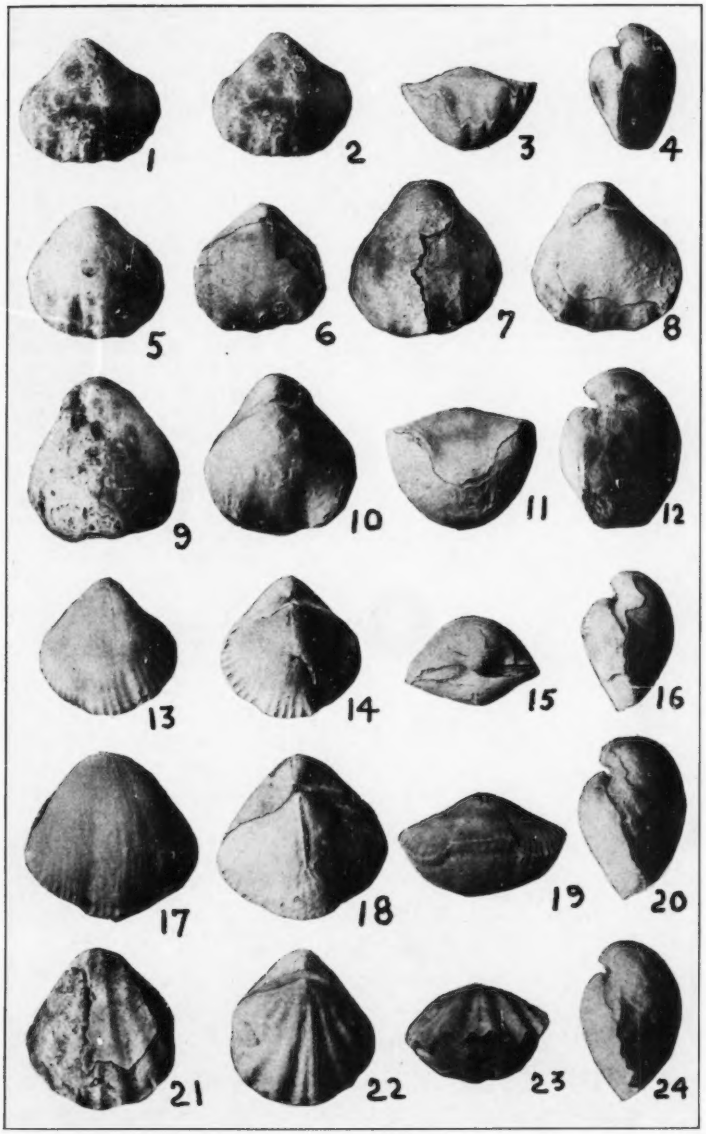


PLATE 2

FIGURES

1–2. *Pentamerella subarata* sp. nov. Pedicle and brachial views of a paratype, (S.U.I. 6-204), from Littleton, Iowa.

3–9. *Pentamerella dubia* Hall. 3, 9. Pedicle and brachial views, respectively, of two specimens typical of *Pentamerella micula* Hall (M.A.S. 1224). 4. External view of a pedicle valve (S.U.I. 6-190). 5-8. Pedicle, brachial, posterior and lateral views of a hypotype. All from Iowa City, Iowa, (S.U.I. 6-190).

10-12. *Pentamerella* cf. *laeviuscula* Hall. Pedicle, brachial and lateral views of a specimen, Iowa City, Iowa, (S.U.I. 6-200).

13–20. *Pentamerella nitida* sp. nov. 13, 16. Pedicle, brachial, anterior and lateral views of a paratype, an internal mold, Iowa City, Iowa, (S.U.I. 6-207). 17, 18. Pedicle and brachial views of a paratype (M.A.S. 194a). 19, 20. Pedicle and anterior views of the holotype, Johnson County, Iowa, (M.A.S. 194).

21–24. *Pentamerella obsolescens* Hall. 21-23. Brachial, lateral and anterior views of a hypotype, (M.A.S. 256). 24, Pedicle view of another specimen. Both from Brandon, Iowa.

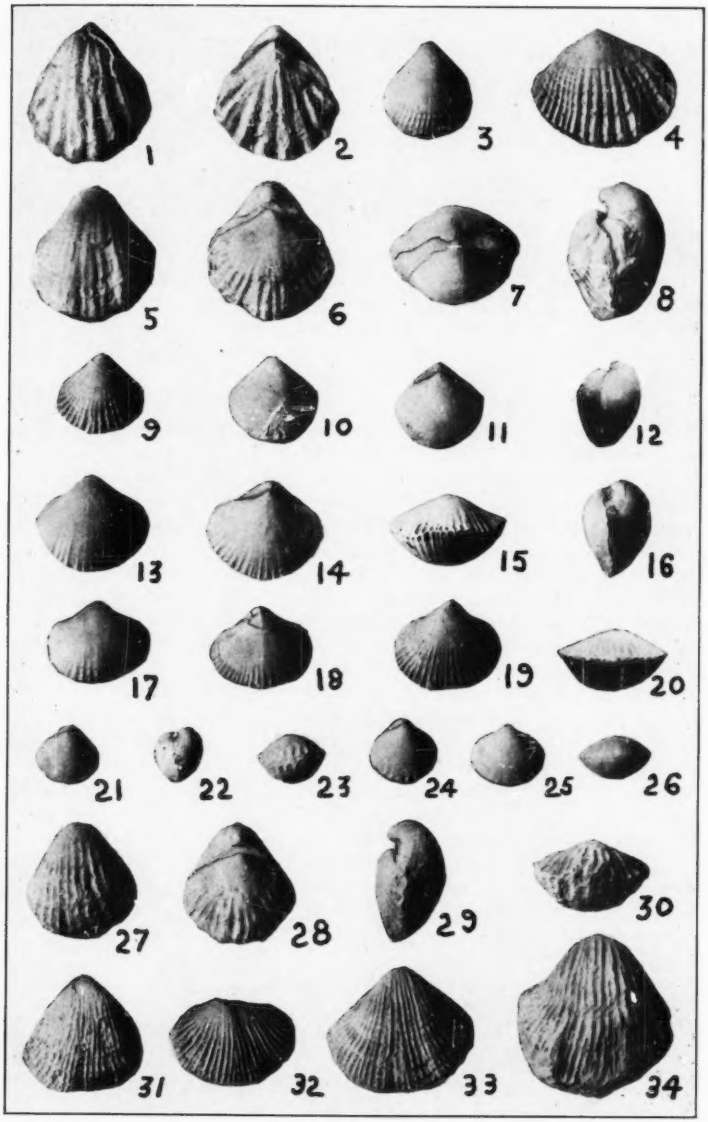
25–26 *Pentamerella laeviuscula* (Hall). Pedicle and anterior views of a specimen. Profunda zone at Brandon, Iowa, (M.A.S. 294).

27–30. *Pentamerella* cf. *multicostata* Cleland. Pedicle, brachial, lateral and anterior views of a specimen from Independence, Iowa, (S.U.I. 6-409).

31–34. *Pentamerella rugosa* sp. nov. 31. External view of a pedicle valve, the holotype, (M.A.S. 113). 32. External view of a pedicle valve, a paratype, (M.A.S. 115). 33. External view of a brachial valve, a paratype, (M.A.S. 115). All above from Brandon, Iowa. 34. Pedicle view of a large complete specimen. Iowa City, Iowa, (S.U.I. 6-191).

(All figures are natural size.)

PLATE 2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A Cranium of the Extinct Moose, Cervalces, from the Quarternary of Northern Indiana[1]

C. Lewis Gazin

A portion of a moose skull belonging to the extinct genus *Cervalces* was found by Mr. Alton Bernhardt, of North Liberty, Indiana, in the headwaters of the Kankakee River. The skull was reported uncovered in a marl-like soil about 6 feet below the surface at the time a drainage ditch was being dug through Potato Creek, about three quarters of a mile north and a mile east of North Liberty in St. Joseph County. The specimen, U. S. N. M. no. 15494, collected in December of 1936, was recently presented to the U. S. National Museum through the kind offices of Dr. Marcus W. Lyon of South Bend.

This is the second find of *Cervalces* in the state of Indiana. A right antler from the White River in the southern part of the state was described by E. S. Riggs[2] in 1936.

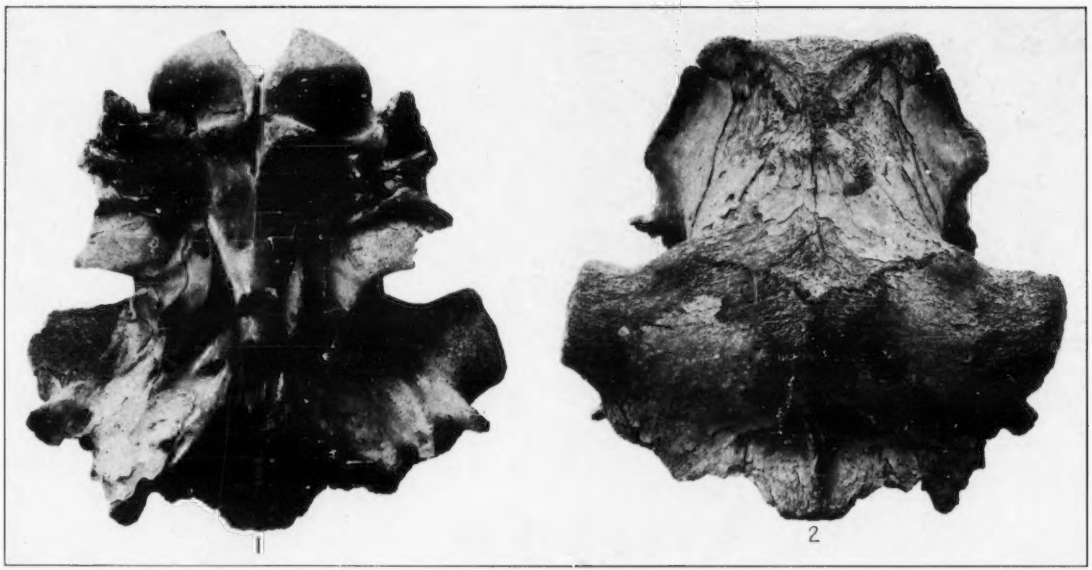
The North Liberty specimen comprises the cranial portion of the skull, but lacks the horns. It is unfortunate that the facial portion anterior to the cribiform plate is missing, as the most important characters in distinguishing *Cervalces* from *Alces* are to be found in the proportions of the rostrum, and especially in the length of the nasal bones. However, the slight development of the median knob on the frontal ridge between the horns and the shallowness of the frontal depressions anterior to this ridge are indicative of *Cervalces* rather than *Alces*, as noted by Scott[3] in his characterization of *Cervalces*. Also, the occipital region is less markedly concave than in *Alces*, and the basisphenoid and anterior portion of the basioccipital are broader. The general proportions of the cranium, however, are not appreciably different than in *Alces*, and the width of the frontals at the constriction between the orbits and horns is even less than in several adult males of *Alces* that were examined.

The *Cervalces* specimen may be immature, as nearly all the sutures on the cranium are more open than in the adult *Alces* and the bases of the antlers are relatively small and distinctly spongy in texture.

The species of *Cervalces* represented is not recognized as the specimen appears to be immature, and in the absence of horns comparisons with some of the types that have been described cannot be made.

1 Published by permission of the Secretary of the Smithsonian Institution.
2 E. S. Riggs. Amer. Midl. Nat., vol. 17, no. 3, p. 664, 1936.
3 W. B. Scott. Proc. Acad. Nat. Sci., Philadelphia, 1885, pp. 181-202 (187), figs. 1-7, pl. 2, 1886.

Division of Vertebrate Paleontology,
U. S. National Museum,
Washington, D. C.



Figs. 1-2: *Cervalces* sp. Cranial portion of skull. U.S.N.M. no. 15494. (1) Ventral view. (2) Dorsal view. x1/3 (approximately).

Book Reviews

MARINE ALGAE OF THE NORTHEASTERN COAST OF NORTH AMERICA. By William Randolph Taylor, illustrated by Chin-Chih Jao. University of Michigan Studies, Scientific Series, Volume XIII. University of Michigan Press, Ann Arbor, 1937. ix + 427 pp., 60 pls. $5.00.

While the algal flora of the Pacific Coast of America had been competently treated in recent years algologists working on the Atlantic Coast lacked an adequate treatise for half a century. Consequently they will be greatly obligated to Prof. Taylor for having prepared such a work and will readily congratulate him on its excellence.

The "Area Surveyed" ranges from Virginia to the eastern American Arctic and west inclusive of Hudson Bay. Other chapters of the "Introduction" are concerned with "Geographical Distribution, Algal Habitats, Collection and Preservation, Historical Survey, Purposes and Limitations." The inclusion of a "Systematic List" is not only commendable but also very helpful in the perusal of the book. Obviously the greater part of the work is given over to the "Descriptive Catalogue" (pp. 24-380). A general key has been purposely omitted for according to the author even a short acquaintance with algae enables the student "to resort directly to the keys under the genera." This omission may, however, be considered by some as the only flaw of the work. In the treatment of the individual genera the author has for most part drawn up entirely new descriptions based on his own studies but with due consideration of recent morphological investigations. "References" help the student of special problems. Most genera are illustrated by habit sketches as well as certain anatomical details. Nearly all of these plates are Dr. Jao's work and rival the text in excellence. Needless to say they add their share to the value of the book. A carefully prepared "Bibliography" (pp. 381-405) is evidence of the scattered character of the available information as consulted and used by the author.

The volume is indispensable to American botanists who will not hesitate to appraise it as among their best products.—TH. JUST.

FAKTORENKOPPELUNG UND FACTORENAUSTAUSCH bei normalem und aberrantem Chromosomenbestand. Von Wilhelm Ludwig. Probleme der theoretischen und angewandten Genetik und deren Grenzgebiete, redigiert von W. F. Reinig. Georg Thieme, Leipzig, 1938. 245 pp., 74 figs. Paper bound RM 11.00.

The series of which this volume is the last installment aims to present in concise form the problems of theoretical and applied genetics and their neighboring fields for the benefit of a large group of intelligent readers who are not geneticists but are nevertheless interested in phenomena of inheritance for various reasons. Some 50 volumes are scheduled for publication five of which (inclusive of this) have so far been issued.

Linkage and crossing-over are among the very foundations of the "theory of the gene" as now understood and accepted. They offer also some of its most crucial problems. While the author did not attempt to prepare a monograph he certainly succeeded in writing an admirable and up to date summary of the many recent and widely scattered contributions pertaining to these problems not omitting their mathematical aspects developed only yesterday one might say. This is shown by the appended bibliography (pp. 219-237) which is despite its length admittedly incomplete.

The author is primarily concerned with the genetical aspects of linkage and crossing-over and only secondarily with the coordination of this knowledge with cytological results. Consequently the organization of the book follows this plan. An "Introduction" acquaints the general reader with the genetical and cytological principles involved.

The main part treats of the genetical theory of linkage and crossing-over and their cytological basis. Space does not permit a more detailed description of the contents, however fascinating and controversial it may be. On the whole Darlington's theories are accepted as the most probable and plausible although it is pointed out clearly what remains to be done before a final solution of all difficulties is found.—TH. JUST.

AN ECOLOGICAL GLOSSARY. Compiled by J. Richard Carpenter. University of Oklahoma Press, Norman, 1938. ix + 309 pp., appendix (i-xii). $4.00.

Among the biological sciences ecology leads today in the attempt to unify the study of plant and animal life on common grounds instead of the conventional pursuit of these investigations along more or less independent lines. Such effort toward synthesis is highly commendable and incidentally very profitable. "An Ecological Glossary" is notable evidence of what can be accomplished on this basis. Its author hopes to reach a clearer understanding of the rich, and sometimes rather ambiguous terminology by careful compilation of the terms in use and by the presentation of adequate definitions, thus assisting materially in paving the way for closer cooperation among ecologists in general.

The "Preface" presents in addition to certain indispensable reference works, the principles employed in the preparation of the glossary. It is followed by a short account of "The Development of Ecological Nomenclature" in which one misses such outstanding names as Kerner, Hayek, Gams, Bews et al. The "Glossary" itself (pp. 11-297) contains some 3000 definitions of varying length and exactitude. As the author himself admits, this number in no way exhausts the available terms yet is a good indication of the task encountered by him in the compilation of this work. No doubt this is also an important reason why certain terms are not included and why others given are treated with such variation in space allotted. Apart from the terms whose definitions were taken directly from Jackson and hence are rather brief, many others were given more space (often involving definitions of various uses) as well as cross references, indication of original sources or some competent recent exposition of them, e.g. "association" (pp. 28-30). From the standpoint of successful usage it is deplorable that a considerable number of misprints were overlooked, especially in foreign words and in the bibliographies. Obviously opinions will always differ regarding the inclusion and exclusion of certain material or the definitions presented. Eight pages of partially overlapping bibliographies conclude the "Glossary." One might readily recommend the citation of other very pertinent sources conspicuous by their absence. The "Appendix" consists of twelve individual maps and tables some of which are here reproduced for purely historic interest and inaccessiblity whereas others are definitely useful in connection with the main part of the book. A map of the floristic regions of the world would have been as deserving of inclusion as one of the "faunistic realms."—TH. JUST.

THE FLORA OF VERMONT. An Annotated List of Ferns and Seed Plants of the State of Vermont. Compiled by a Committee of the Vermont Botanical Club, E. J. Dole, Editor. Burlington, Vt., 1937. 3. rev. ed. xv + 353 pp., frontispiece. $0.50.

The present edition of "The Flora of Vermont" lists 2,572 fernworts and seed plants known to occur within the state and definitely substantiated by herbarium specimens. In addition others are listed for various reasons such as being represented only by varieties or forms etc. Critical information of nomenclatorial, distributional, and taxonomic character is given for all species. The nomenclature is very much more up to date than that of many manuals and this ensures the usefulness of the book to botanists elsewhere. In this respect it is regrettable, however, that not all genera were treated with equal care. A "History of Vermont Botany" and "Geologic Features Controlling Plant Distribution in Vermont" furnish a good introduction to the "Cata-

logue." A series of "Supplementary Tables" listing new combinations etc. and two elaborate indices conclude the book. Undoubtedly much joint effort has been exerted to make this edition as reliable and useful as possible although such popular abbreviations as "Monocots" and "Dicots" could have profitably been avoided in an otherwise scientific enterprise.—TH. JUST.

SCIENTIFIC ILLUSTRATION. By John L. Ridgway. Stanford University Press, Stanford University, 1938. xiv + 173 pp., colored frontispiece, 22 pls., 23 figs., 17 tables. $4.00.

Relatively few scientific publications disregard today the advantages obtained by the use of illustrative material. Yet conspicuous variation in the quality and effectiveness of such material is readily noticeable even upon a very superficial examination of scientific literature. To aid in the possible elimination of such discrepancy by the maintenance of the highest standards in the preparation and reproduction of scientific illustrative material is the principal aim of the author of "Scientific Illustration." Only secondarily is he concerned with its possible use as a textbook although the field covered by it is almost untouched in this respect. Himself an accomplished artist of international fame and backed by many years of practical experience in the services of the U. S. Geological Survey, the Carnegie Institution of Washington and the California Institute of Technology the author is eminently qualified to record his best advice on all phases of scientific illustration and thus assist authors, artists, and editors in the selection of the most suitable type of illustration as well as its most effective reproduction. While the author does not intend to offer a course in freehand drawing he describes special methods employed to produce "finished illustrations." The attitude assumed throughout the book is conservative and dismisses deliberately certain "modernistic tendencies." The wide range of topics covered indicates at once the thoroughness with which the book was prepared and the many problems encountered in such work. Many critical points are illustrated by figures and plates for the most part drawn by the skillful hand of the author. The "Appendix" contains 17 tables of very useful and practical data, e.g. co-ordinates of curvature, etc. The physical appearance of the book is wholly in keeping with the high standards set by its author for "Scientific Illustration."—TH. JUST.

NATURE PHOTOGRAPHY AROUND THE YEAR. By Percy A. Morris. D. Appleton-Century Company, New York, 1938. xviii + 251 pp., 14 figs., 96 pls. $4.00.

Despite the large number and varying quality of available "nature" books, *Nature Photography around the Year* represents a valuable addition since it aims at a twofold purpose. First its author hopes to assist the nature lover with inadequate photographic experience and secondly to aid the experienced photographer who has a limited acquaintance with natural history. This aim the author seems to have accomplished very well by mixing admirably sound practical information on photography with an all-year round program of activities and helpful descriptions of attractive nature objects available throughout the year beginning with March. Thus e.g. color photography is treated under "April" since the first really colored flowers appear then whereas "Indoor Photography" is reserved for the winter months of which February is the poorest and therefore concludes the book. A selected bibliography (3 pp.) will assist those who wish to carry their work beyond the scope of the present volume. Most of the photographs reproduced on the 96 pls. were taken by the author and are the best evidence of his qualification for the preparation of this competent and at the same time delightful book.—TH. JUST.

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